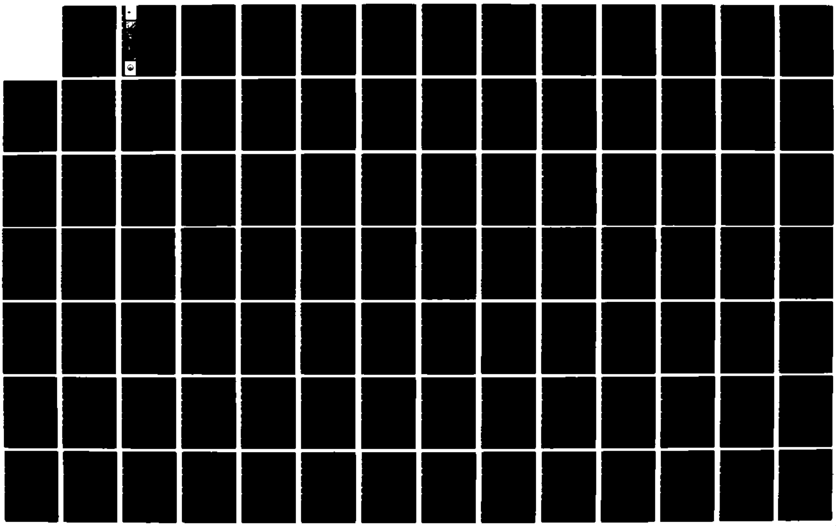
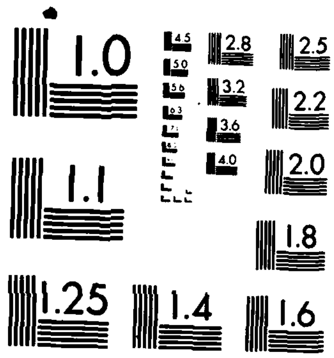
AD-A161 548 ANNOTATED BIBLIOGRAPHY OF SEDIMENT TRANSPORT OCCURRING OVER EBB-TIDAL DELTAS(U) ARMY ENGINEER WATERWAYS EXPERIMENT STATION VICKSBURG MS GEOTE 1/2

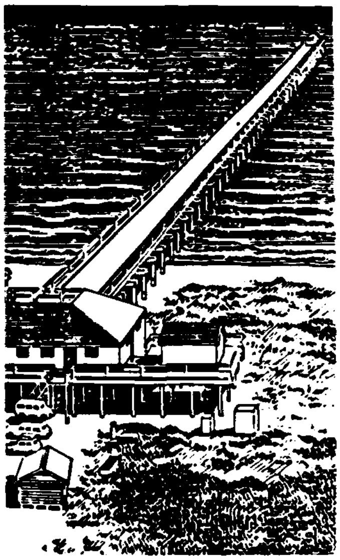
UNCLASSIFIED L L WEISHAR ET AL SEP 85 WES/MP/CERC-85-11 F/G 8/3 NL





MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

US Army Corps
of Engineers



(12)

MISCELLANEOUS PAPER CERC-85-11

ANNOTATED BIBLIOGRAPHY OF SEDIMENT TRANSPORT OCCURRING OVER EBB-TIDAL DELTAS

by

Lee L. Weishar, M. Leslie Fields

Coastal Engineering Research Center

DEPARTMENT OF THE ARMY
Waterways Experiment Station, Corps of Engineers
PO Box 631, Vicksburg, Mississippi 39180-0631

September 1985
Final Report

Approved For Public Release; Distribution Unlimited

Prepared for DEPARTMENT OF THE ARMY
US Army Corps of Engineers
Washington, DC 20314-1000

Under Inlet Channel Stability Work Unit 31716

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER Miscellaneous Paper CERC-85-11	2. GOVT ACCESSION NO. AD-A161	3. RECIPIENT'S CATALOG NUMBER 548
4. TITLE (and Subtitle) ANNOTATED BIBLIOGRAPHY OF SEDIMENT TRANSPORT OCCURRING OVER EBB-TIDAL DELTAS		5. TYPE OF REPORT & PERIOD COVERED Final Report 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Lee L. Weishar M. Leslie Fields		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS US Army Engineer Waterways Experiment Station Coastal Engineering Research Center PO Box 631, Vicksburg, Mississippi 39180-0631		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS Inlet Channel Stability Work Unit 31716
11. CONTROLLING OFFICE NAME AND ADDRESS DEPARTMENT OF THE ARMY US Army Corps of Engineers Washington, DC 20314-1000		12. REPORT DATE September 1985 13. NUMBER OF PAGES 129
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this report) Unclassified 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

Available from National Technical Information Service, 5285 Port Royal Road, Springfield, Virginia 22161.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Sediment Transport--Bibliographies (LC)
Tidal Inlets (WES)
Deltas--Bibliographies (LC)

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Abstracts and annotations are given for 205 published reports, dated 1984 and earlier, on the engineering and process response aspects of tidal inlet systems. This report has been compiled to update the General Investigations of Tidal Inlets Report 4 to the present decade. Emphasis is placed on coastal processes at tidal inlets. The inlet back-bay regions have been viewed as interrelated systems which are dynamically dependent upon each other. Therefore, a perturbation of any part of the system will partially dictate the response of the remaining part.

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

Preface

This bibliography was prepared by Dr. Lee L. Weishar and Ms. M. Leslie Fields, Coastal Processes Branch, Research Division, of the Coastal Engineering Research Center (CERC), US Army Engineer Waterways Experiment Station (WES). The work was completed as a part of the Inlet Channel Stability Work Unit 31716 of the Harbor Entrances and Coastal Channels Program. Technical monitors from the Office, Chief of Engineers, were Mr. John H. Lockhart, Jr. and Mr. John G. Housley. References were assembled during a literature survey made to provide background material for a study of shoaling processes which occur on ebb-tidal deltas.

The work was done under general supervision and direction of Mr. H. Lee Butler, Chief, Coastal Processes Branch, Dr. James R. Houston, Chief, Research Division, Dr. Robert W. Whalin, former Chief, CERC, and Mr. Charles C. Calhoun, Jr., Acting Chief, CERC.

COL Robert C. Lee, CE, was Commander and Director of WES during the preparation of this bibliography; Mr. Fred R. Brown was Technical Director. At the time of publication, COL Allen F. Grum, USA, was Director of WES and and Dr. Whalin was Technical Director.

CONTENTS

ANNOTATED BIBLIOGRAPHY ON SEDIMENT TRANSPORT OCCURRING OVER EBB-TIDAL DELTAS

Introduction

1. Over the past several years there have been a few large-scale and a great number of small-scale studies conducted by the Government and in the private sector which deal with problems of sediment transport. One of the primary objectives of these studies has been to quantitatively describe, predict, and/or model sediment transport in widely diverse environments ranging from subaqueous submarine canyons to the extraterrestrial environment of Mars. The US Army Corps of Engineers (USACE) maintains an active interest in sediment transport in the more classical context of the terrestrial subaerial and subaqueous environments. The primary reason USACE maintains this active interest in sediment transport is that developing a better quantitative understanding of this process will provide engineers with a better tool to make more accurate predictions which will lead to a wide variety of benefits, one of which will be better designs of coastal structures. A better quantitative understanding of sediment transport will ultimately lead to better planning and management of rivers, streams, beaches, and nearshore regions.

2. Each year the operating Divisions and Districts of USACE spend hundreds of millions of dollars maintaining navigable waterways. Maintenance of these waterways entails construction of protective structures, maintenance dredging, and new work dredging. Over 80 percent of USACE's efforts in the maintenance of navigable waterways is devoted to management of sediment and problems related to sediment transport. The ability to increase the efficiency of structures and/or channels will decrease dredging requirements and ultimately lead to an increase in the life of a project. If the dredging frequency can be decreased, USACE will realize a real savings.

3. There are only three viable engineering alternatives for decreasing dredging frequency and reducing project costs. The first alternative is to increase the efficiency and capacity of dredges. The second alternative involves the overdesign of projects utilizing larger and deeper channels. This alternative cannot be globally applied due to the impracticality of the solution in many locations. In addition, dredging larger and deeper channels has a wide range of environmental impacts. The last alternative involves obtaining a quantitative understanding of the sediment transport process. Only through gaining better insight into this process will engineers and scientists be able to design better and more efficient structures and navigation channels.

Background

4. This annotated bibilography is the culmination of over 2 years of effort. At present there are several annotated bibliographies which address

the problem of waves, currents, and inlet processes. The most notable of these annotated bibliographies was completed under USACE's research program entitled General Investigation of Tidal Inlets (GITI). The work is not intended to duplicate the previous GITI bibliography and contains no replications; however, it does utilize the GITI document for supplemental information.

5. This bibliography has been specifically compiled to address the problems of sediment transport in channels extending through ebb-tidal deltas. During the course of research, the impossibility of addressing the ebb-tidal delta as a spearate and/or independent entity became apparent. Ebb-tidal deltas, existing in one of the most dynamically complex regions of the subaqueous environments, are located on the seaward side of tidal inlets. Exposed to the complex processes of the inlet-nearshore region, ebb-tidal deltas exist in an environment composed of three distinct dynamic zones. Zone one is located near the inlet and, in many cases, directly in the inlet throat. This zone is dominated by inlet processes which are composed of long wave (tide) backbay interaction. Also important in this region is the interaction of longshore sediment transport and the efficiency of the inlet. This interaction is important because it directly impacts on the availability of sediment to the ebb-tidal delta. Zone two is located immediately offshore of zone one. This zone is a complex region which is the dynamic interfall between zone one (which is dominated by inlet processes) and the offshore region, zone three (which is dominated by wave-current interaction). Zone two is the most complex region because of the interaction between reversing currents produced by the inlet jet and the combination of oscillatory flows produced by the interaction of short-term oscillatory motion resulting directly from the passage of the wave form and the longer period wave-generated oscillatory flows known as longshore current. Zone three is located farther offshore of zone two and becomes increasingly dominated by wave processes. Farther offshore the depth increases, resulting in a decreasing influence of inlet processes and wave-generated longshore currents. On the outer edge of the ebb-tidal delta there is only the oscillatory bottom motion associated with the passage of waves.

6. Superimposed upon the dynamic processes described above is the basic problem of sediment transport and inlet efficiency. If there is no sediment available to the system then there will be no ebb-tidal delta. If there is sediment available to the system, then inlet efficiency becomes extremely important in determining the quantity of sediment available to the ebb-tidal delta. If the inlet is highly inefficient at bypassing material, large quantities of material will reside in flood-tidal deltas, and the ebb-tidal delta will be diminutive. However, if the inlet is highly efficient at bypassing sediment, then there will be the potential for large quantities of sediment to be transported across the ebb-tidal delta bar.

7. It is apparent from the above abbreviated discussion that the entire nearshore-inlet system must be considered when examining the problem of sediment transport in an ebb-tidal delta. Therefore, the annotated bibliography addresses areas of wave-current interactions, inlet hydrodynamics, inlet hydraulics, and sediment transport. Literally thousands of abstracts were obtained and scrutinized to determine their applicability. Once this determination had been made the companion documents were obtained. As stated, in

order to prevent duplicating previous work, articles contained within existing bibliographies are not presented. Therefore, this document is supplemental in nature. It is, however, as complete as possible for the previous 10 years. Papers which deal specifically with the sediment transport process in the region of the ebb-tidal delta will be addressed later in a detailed literature review.

ANNOTATED BIBLIOGRAPHY ON SEDIMENT TRANSPORT
OCCURRING OVER EBB-TIDAL DELTAS

A

0001 **ACKERS, P. and WHITE, W.R.** 1973. Sediment transport: New approach and analyses: Jour. Hyd. Div., Proc. Amer. Soc. Civ. Engr., 99(HYII):2041-2060.

A new framework for the analysis of sediment transport data is presented. The calculated parameters which define sediment transport are D_{gr} (grain size), F_{gr} (mobility), and G_{gr} (transport). The data base for the transport functions consists of nearly 1,000 flume experiments conducted with uniform grain sizes in depths of flow up to 0.4 m. The authors show that movement of fine-grained materials (<0.04 mm) is closely related to shear velocity, whereas, the transport of coarse material (>2.5 mm) is best related to mean current velocity. (Fields)

0002 **AMEIN, M.** 1975. Computation of flow through Masonboro Inlet, N. C.: Jour. Waterways and Harbor Div., Proc. Amer. Soc. Civ. Engr., 101(WW1):93-108.

The author discusses the development and testing of a numerical simulation model for the determination of tidal and freshwater flow exchange through tidal inlets. The model is based on the equations of unsteady flow in open channels. Masonboro Inlet, North Carolina, was selected as the test inlet. Required input for the model includes channel cross-sectional properties, the friction coefficient, and boundary data. The values of average water velocity, water discharge, and water depth can be computed by the model. A comparison of the computed results with the field data from Masonboro Inlet suggest that the simulation model can accurately determine the hydraulic characteristics of tidal inlets. (Fields)

0003 **ARCINIEGA, J.R.L.** 1975. Shoreline changes due to jetty construction on the Oregon coast: M.S. Thesis, Oreg. State Univ., 75 pp.

Patterns of beach erosion and accretion due to jetty construction are examined for the coast of Oregon. All jetty systems are included with the exception of those on the Columbia River, a total of nine systems.

All evidence indicates that these areas of the Oregon coast are experiencing a seasonal reversal in the sand drift, but with a zero or near zero net drift over a long period of time. Thus, shoreline changes resulting from jetty construction are not the usual examples of jetties blocking a net drift as found in southern California and elsewhere.

In general, accretion of the shoreline took place adjacent to the jetties following their construction, both to the north and south. This accretion resulted mainly from the embayment formed between the jetty and the prejetty shoreline, the embayment becoming filled until the shoreline is straight and again in equilibrium with the waves such that there is a zero net prejetty shoreline, the embayment becoming filled until the shoreline is straight and again in equilibrium with the waves such that there is a zero net sand drift. In some cases, as the entrance to Yaquina Bay, the jetties are oblique to the trend of the shoreline and so produced a protected zone from the waves where accretion could occur.

Sand for the accretion adjacent to the jetties was derived from beach erosion at greater distances from the jetties. The severity of the erosion depended on the total amount of sand required for the beach accretion to a new equilibrium, and to the length of beach that was undergoing erosion. When only a short stretch of beach occurs to one side of the jetties, as at Bayocean Spit, then the resulting erosion was particularly severe, in that case leading to the breaching of the spit.

A computer model is developed to simulate the shoreline changes that occurred following construction of the jetties on the Siuslaw River mouth. The model demonstrates deposition next to the jetty to fill the embayment created by the jetty, and erosion at greater distances from the jetty. The shoreline advances of the model agreed closely with the actual shoreline changes found in surveys following jetty construction. (Author)

004 **ARIATHURAI, R., GOLDEN, J., McANALLY, W.H., STOUT, G.A., and NEIHEISEL, J.** 1983. Shoaling processes in navigable waters: Jour. Waterways and Ports Div., Proc. Amer. Soc. Civ. Engr., 109(2):199-221.

The paper gives a description of the magnitude and character of shoaling in the nation's waterways and harbors, including the physical and chemical processes by which sediment accumulation occurs. The effects of estuarine hydrodynamics (oscillatory tidal flow and vertical circulation), sediment character, and water chemistry are discussed in relation to how they control shoaling processes. (Fields)

005 **ASHLEY, G.M., HALSEY, S.D., and FARRELL, S.C.** 1981. Growth and modification of an ebb-tidal delta sand body in response to changes in sediment supply and hydrographic regime (Abs.): Geol. Soc. Amer. Abs., 13(3):121.

Barnegat Inlet (BI) is one of the several major breaches in the barrier island system fringing the low mesotidal coastline of New Jersey. An ongoing analysis of changes occurring in the configuration and volume of the (BI) ebb-tidal delta sand body indicates specific responses to: (1) variations in direction of net longshore drift, (2) change in available sediment supply, and (3) the stabilization of the inlet by jetties. The continuous southward migration of the inlet during the last 125 years suggests a net longshore drift to the south; however, periodic reversals (up to a few years in length) in this long-term trend, as well as a local reversal associated with wave refraction around the ebb-tidal delta, is indicated. Sediment available to the drift system has come naturally from eroding barriers (up to 5 m/yr per lin m of beach) and artifically from a replenished beach (900,000 m^3 was pumped from the inlet channel to critically eroded beaches to the south). The inlet was stabilized (1938-40) with a pair of nonparallel (weir) rock jetties. Important changes in hydrography and sediment distribution since stabilization include the interrelated effects of a decreased tidal prism

($1.95 \times 10^6 m^3$ in 1945 to $1.13 \times 10^6 m^3$ in 1980) and increased sedimentation both landward and seaward of the jetties. Calculations from detailed bathymetric maps show that the ebb-tidal delta has increased 300 percent in volume from 150,000 m^3 (1968) to 450,000 m^3 (1979, just prior to the beach replenishment project) and delta growth rate has accelerated since replenishment. Geometry of the sand body created by the migrating inlet-tidal delta complex is 6-10 m thick, 3 km wide, and indefinite in length. (Authors)

006 **AUBREY, D.G., and SPEER, P.E.** 1982. Sediment transport in a tidal inlet: Army Research Office, Research Triangle Park, N. C., Rpt. No. ARO-16710 8-GS, 2:112.

Various aspects of sediment transport in and around natural, unstructured tidal inlets were investigated over the two-year period of the study. Concentrating on two tidal inlets (Nauset Inlet and Popponesset Inlet, Cape Cod, Mass.), and combining detailed field observations with numerical model studies of tidal flows in inlet/estuarine environments, several aspects of tidal inlet behavior have been clarified. In addition, fieldwork has resulted in a number of technical publications of general utility to a wide spectrum of coastal research interest. Primary scientific items addressed in this study include: (1) diagnostic numerical model of generation and propagation of tidal nonlinearities in shallow estuarine channels; (2) effects of flow curvature on tidal inlet sediment transport; (3) definition of mechanisms by which tidal inlets migrate in a direction opposite to the net littoral drift direction, (4) hypothesis of a mechanism for rapid barrier spit growth in locations with low rates of littoral transport; (5) clarification of long-term patterns of sea-level rise in the United States to assess its role in tidal inlet/estuarine evolution; (6) historical descriptions of massive inlet migration at two studies includes a description of a low-cost, reliable method to join nearshore electrical cables, description and intercomparison of instrumentation and analysis routines for estimating directional spectral parameters from wave gage data; and a development of a field system and laboratory analysis package for preparing accurate bathymetric charts in shallow, nearshore regions, using microwave navigation and precision echo-sounding. (Authors)

B

0007 **BARWIS, J.H. and HUBBARD, D.K.** 1976. The relationship of flood-tidal delta morphology to the configurations and hydraulics of tidal inlet bay systems (Abs.): Geol. Soc. Amer. Abs., 8(2):129.

The morphology of flood-tidal deltas is controlled by the configurations of the bays in which they occur. An aerial photographic investigation of over 100 North American tidal inlets has characterized two major types of inlet-bay systems: inlets associated with a shallow open bay (type A), and inlets associated with a channelized marsh system (type B). These configurations produce markedly different ratios of bay to ocean tidal amplitude (a_b/a_o). The spatial and temporal distribution of current velocities, and thus the morphology of the resultant sand body, are distinct in each case.

In type A inlets, where a_b/a_o is small, current velocities are highest in the inlet throat and decrease rapidly away from the inlet. Sand transported into the bay by flood-tidal currents is deposited as a fanlike sheet that radiates from the inlet throat. Local hydraulics determines whether the deposit is single or multilobate with minor ebb spillover lobes, or whether it is digitate with alternating flood and ebb channels. In type B inlets, where a_b/a_o is larger, tidal current velocities decrease more uniformly away from the bayward end of the inlet channel. Sand bodies occur where current velocities are low enough to initiate sedimentation, which may be kilometers from the main entrance. Three types of channel-associated sand bodies occur: current-parallel sand stringers, sinuousoidal shoals, and shielded ramp shoals. The morphology of a particular sand body is controlled by the degree of time-velocity asymmetry, and by the segregation of ebb- and flood-tidal currents. In wider type B inlets, waves effectively alter the tidally induced forms found near the inlet throat, and often produce flood ramp that are welded to the adjacent marsh. (Authors)

0008 **BEHRENS, E.W., WATSON, R.L., and MASON, C.** 1977. Hydraulics and dynamics of New Corpus Christi Pass, Texas: A Case History 1972-1973: GITI Report 8, US Army Corps of Engineers, Fort Belvoir, Virginia, 127 pp.

In 1972, a 2-mile channel was dredged through Mustang Island, Texas, to increase water exchange and fish migration between Corpus Christi Bay and the Gulf of Mexico. The pass' initial adjustment to tides, waves, and other forces was measured the first year following the opening. Hydraulic and sedimentary effects of the pass were studied by obtaining detailed bathymetric, topographic, and hydraulic surveys of the pass and adjacent gulf beaches; daily wave observations provided information on the seasonal variability in wave height, period, and direction. An estimated 1 million cubic yards of sand accumulated at the pass during construction of two gulf jetties. Thereafter, a loss of sand greater than the estimated net annual longshore transport rate occurred on beaches south (downdrift) of the jetties. Considerable sediment was deposited on shoals at the bay end of the pass with little accumulation in the pass. Hydraulic measurements indicate that channel frictional resistance increased by about 50 percent over the study period, although greater variability occurred during individual tidal cycles. Tidal discharge through the pass was highly dependent upon variations in the gulf discharge through the pass was highly dependent upon variations in the gulf tides, with equal volumes of ebb and flood flows during diurnal tides and strong flood predominance during mixed and semidiurnal cycles. The average discharge through the pass was only about 3 percent of the total tidal prism of Corpus Christi Bay, indicating that the bay tides, which partly control flow through the pass, result primarily from passage of the tide through Aransas Pass, the major bay-gulf connection.

The pass was marginally stable during the first year, but the wide range of climatic conditions in the region will probably cause the pass to be stable in some years and unstable in others. Although the pass undoubtedly influences bay water within the immediate vicinity, no significant effect on flushing of Corpus Christi Bay resulted from the pass construction. (Authors)

009 **BIJKER, E.W.** 1980. Sedimentation in channels and trenches: Conf. Coas. Engr., 17th, Proc., 1708-1718.

In this paper the siltation in approach channels and trenches due to cross currents and waves is discussed. It is in this respect not necessary that the current crosses the channel at a right angle. When the current crosses the channel obliquely simply a greater distance over which the water flows over the greater depth is introduced. Deviations in the flow pattern--see Figure 1--due to the channel are neglected. When the flow pattern is known, either from measurements in nature or in model, this effect can easily be introduced. The influence of the waves is introduced through the introduction of an increased bed shear and subsequently higher diffusion coefficient.

Although computer programs are available to compute the siltation under the above-described circumstances, an attempt will be made to come to a relatively simple method which enables a quick estimate of the siltation to be expected without the requirement of a big computer. This method could be especially useful for the engineer in the field who has to make the first appraisal for the various solutions. (Author)

010 **BOON, J.D.** 1975. Tidal discharge asymmetry in a salt marsh drainage system: Lim. and Oceanog., 20(1):71-80.

Tidal discharge and area-averaged current speed were measured over complete tidal cycles at the entrance to a salt marsh drainage system near Wachapreague, Virginia. A pronounced asymmetry in curves of discharge and current speed through time was observed which can be simulated by a model incorporating semidiurnal tides and "overtides" in conjunction with marsh and channel storage relationships. As a persistent feature in marsh channel flow relationships, the asymmetry, along with an apparent difference in flood and ebb maxima, may have a systematic, long-term influence on the net transport of suspended matter entering and leaving natural marshes. (Author)

011 **BOON, J.D., and BYRNE, R.J.** 1981. On basin hypsometry and the morphodynamic response of coastal inlet systems: Mar. Geol., 40:27-48.

The exchange of water and entrained material between coastal basins and the inner continental shelf reduces to the problem of polarized transport (flood +, ebb -) in the conveyance channels routing flow through a coastal inlet. Here the net long-term movement of materials is largely a function of the fluid velocity and discharge--variables whose time-history at a station contains both periodic and aperiodic elements. In this paper the importance of the major periodic elements in coastal inlet flows and their potential contribution to the net transport of bed-load materials is discussed.

With the aid of a numerical model featuring a closed hypsometric (area-height) representation of basin storage-volume--channel-flow relationships in a typical basin and inlet system at Wachapreague, Virginia, on the East Coast of the United States were studied to determine present mechanisms for inducing net flood or ebb bed-load transport. The basin hypsometry and channel dimensions of the prototype system were then varied in the model to simulate other conditions that may have prevailed during earlier stages of basin evolution. Given a sine wave input to the model, the principal lunar semidiurnal constituent (M_2) and its first-harmonic overtide (M_4) respond in a predictable way to differences in basin hypsometry and channel configuation, and these constituents in turn account for distinctive rise and fall duration differences observed in the mean tide within the basin. These distortions in basin tides are also reflected at a station in the time-histories of channel discharge and velocity in the form of greater peak magnitudes during ebb or flood depending upon which phase has the shorter duration, and depending in some instances on a further modulation by basin hypsometry and channel cross-sectional area. A consistent imbalance between peak flows of opposing direction is a plausible mechanism for long-term, net transport, or bottom sedimentary materials.

Thus, it appears that a systematic contribution toward either flood or ebb dominance in channel flows can arise through complex periodic tides that exist as a result of specific morphological features in basin and inlet systems. The primary significance of these periodic mechanisms may lie in their apparent sensitivity to changes in basin hypsometry. (Authors)

012 **BRUUN, P.M.** 1977. Design of tidal inlets on littoral drift shores: Coastal Sediments '77, 5th Sym. of the Waterway, Port, Coas. and Ocean Div., Proc., Amer. Soc. Civ. Engr., 927-945.

The paper includes a summary of design procedures for tidal inlets on littoral drift shores. Four morphologic components of tidal inlets are discussed, including the gorge channel, the ocean entrance channel, the intermediate channel, and the bay channel. The overall stability of an inlet is best described in terms of the Ω/M_{total} ratio, where Ω is the tidal prism, and M_{total} is the total amount of drift material carried to the gorge channel. This is considered by the author to be a more reliable indicator of inlet stability than Escoffiers Stability Concept.

Design of the gorge channel is not efficient when based on detailed tidal hydraulic computations. The mean maximum velocity at spring tide is shown to be useful in describing the cross-sectional stability of a gorge channel. Entrance channels must be designed based on tidal current distributions, wave energy flux, and shear stress created by waves and currents. Knowledge of the shear stress created by combined tidal currents and oscillatory wave currents is also required for the design of intermediate channels. Most bay channels can be designed as river channels, in which material carried by flood currents is intercepted in sediment traps. (Fields)

013 **BRUUN, P.M.** 1978. Stability of tidal inlets: Elsevier Scientific Pub. Co., Amsterdam, 510 pp.

The text presents a state-of-the-art review of tidal inlet stability. The following chapters are contained in the book, each with its own list of references:

1. Development of tidal inlets.
2. Configuration of tidal inlets.
3. Inlet hydraulics.
4. Sediment transport in tidal inlets.
5. Stability of tidal inlets on littoral drift shores.
6. Design and improvement of coastal inlets.
7. Improvements by dredging of channels and traps.
8. Improvements by structures.
9. Which kind of research is needed. (Fields)

014 **BRUUN, P.M., and GERRITSEN, F.** 1958. Stability of coastal inlets: Jour. Waterways and Harbors Div., Proc. Amer. Soc. Civ. Engr. 84(WW3):1644-1649.

Existing theories of the relationship between tidal range, tidal prism, and inlet cross section are reviewed and compared. Existing data on inlets are introduced into the discussion, as well as the effect of quantity and type of littoral material on the inlet action. (Authors)

015 **BRUUN, D., GERRITSEN, F., and BHAKTA, N.P.** 1974. Evaluation of overall entrance stability of tidal entrances: Conf. Coas. Engr., 14th, Proc., 1566-1584.

This paper is written in continuation of earlier published material dealing with stability of tidal inlets on littoral drift shores. The experience available at that time was responsible for the introduction of two parameters: $V_{mean,max}$, defined as the mean max velocity in the gorge at spring tide, and the Ω/M_{total} ratio (tidal prism at spring tide divided by material transport to the entrance from the adjoining shores) as the most pertinent parameters for description of overall stability. A more detailed justification for this choice is given in this paper, based on computation of the relative sediment transport at various tidal phases. Examples of earlier data and twelve new examples from India are given. (Authors)

016 **BUTAKOV, A.N.** 1971. Study of development and deformation of mouth bar: 14th, Cong. of the Int. Assoc. for Hyd. Res., 4:D12-1-8.

In this study the results of modal and theoretical investigations of mouth bars consisting of river deposits are presented.

A process of mouth bar formation in the conditions of constant in time solid and fluvial runoff and in the case when the solid runoff changes in time have been investigated. Velocity field has been studied when the bed of the sea longshore is plane and it is considered in all the stages of bar formation. Bar deformations have been studied in the conditions of separate and combined action of the riverflow and the waves.

Theoretically the task of bar formation has been studied in the case of the influence of river factors. The differential equation is defined for the velocity field of the flow. The integration of the equation for the general case is given; particular decisions are found. The comparison of theoretical and model field velocities has been presented. The functions defining the initial velocity of bar formation and deformation are given. The bar relief drawn by the suggested method is found in accordance with the bar morphology defined from experiments. (Author)

017 **BUTLER, H. L.** 1978. Numerical simulation of tidal hydrodynamics, Great Egg Harbor and Corson Inlets, New Jersey: Tech. Rpt. H-78-11, US Army Engineer Waterways Experiment Station, CE, Vicksburg, Mississippi, 138 pp.

Great Egg Harbor Inlet and Corson Inlet, located in southeast New Jersey, have been plagued with hazardous navigation conditions and erosion problems. Numerical techniques were used to investigate the tidal hydrodynamics of the inlet complexes for existing conditions as well as for proposed improvement plans. The physical size and complex geometry of the study areas required a simulation model that could be economically applied. Consequently, an inherent part of the study involved development of a numerical model (WI model) based on an implicit finite difference formulation. The model includes treatment of moving boundaries and subgrid-scale barriers. A comparison study with a well-known explicit finite difference tidal model was performed to assure the implicit model's reliability and cost effectiveness. Having demonstrated the WI model capability, the next phase of the study concerned application of the WI model to Great Egg Harbor and Corson Inlets to quantitatively predict the tidal hydrodynamics (exclusive of salt and sediment transport) for existing conditions and various improvement plans. The basic improvements for each inlet are similar. In general, they provide for:

_a_. An upcoast jetty with a weir section for navigation protection and beach erosion control. Bayward of the weir section a deposition basin would be dredged to impound sand transported across the weir section. Periodic maintenance dredging of the deposition basin would provide sand for nourishment of adjacent beaches.

_b_. Construction and maintenance of specified navigation channels.

_c_. A downcoast bulkhead and jetty system together with an optional development of landfill area adjacent to the bulkhead for public recreational use.

Results of the numerical computations indicated that the systems proposed for Corson Inlet appear to function equally well and no detrimental effects were noted. For Great Egg Harbor Inlet, a concentration of ebb flow toward the upcoast deposition basin and structure was noted, suggesting a potential problem which should be recognized for the proposed plans. Time histories of tide elevations and velocities are presented for selected stations throughout each inlet complex. Circulation patterns at each half hour during a complete tidal cycle are presented in film form for the verification conditions and for each plan. (Author)

018 **BYRNE, R.J., and BOON, J.D.** 1976. Speculative hypothesis on the evolution of Barrier-Island-Inlet-Lagoon systems; II. A Case Study, Wachapreague, Virginia (Abs.): Geol. Soc. Amer. Abs., 8(2):159.

The Wachapreague Inlet system appears to have evolved during the Holocene transgression from a situation in which hydrualic conditions induced net transport of littoral sands (into the lagoon) to a hydraulic regime resulting in sand bypassing seaward and storage in the ebb-tidal delta. The Holocene depositional history by other workers shows that an extensive flood delta was formed, which in conjunction with deposition of clay and silt, formed the nucleus for later marsh development (1,000 years BP) with segmentation into lagoonal and tidal flat compartments. However, examination of the system's morphology throughout the last century indicates cessation of flood delta deposition and no continued areal expansion of marsh surface. Analysis of tide records within the system indicates that tidal distortions arise which result in a duration asymmetry between rising and falling stages (rising greater than falling by 0.4 hr). A similar asymmetry is exhibited by the inlet tidal currents but not in the nearshore ocean tide records. As a result of this duration difference the ebb tidal power at the inlet is greater than the flood, accounting for the present-day tendency for the inlet to bypass or store sand in the ebb delta. Spectral analysis of the ocean and lagoon tides shows a dramatic enhancement of the M_4 and M_6 components of shallow-water tides on the interior. Inlet tidal currents also show a strong contribution of these components. These distortions of the tides are sufficient to account for the observed duration asymmetry in current. The study documents a case of inlet-lagoon evolution wherein the interaction between evolving geomorphology and tidal hydraulics resulted in the maintenance of the inlet by an ebb-dominated tidal flow regime. The exact role of basin and inlet morphology on the tidal response remains to be clarified. (Authors)

019 **BYRNE, R. J., DeALTERIS, J.T., and BULLOCK, P.A.** 1974. Channel stability in tidal inlets: A Case Study: Conf. Coas. Eng., 14th, Proc., 1585-1604.

Wachapreague Inlet, a downdrift offset inlet in the barrier island complex of the mid-Atlantic U.S. coast, was studied during the period 1971-1973. Elements of the study included: (1) the inlet morphometric history (120 years), (2) assessment of surficial and subbottom sediments within the inlet complex, (3) response of the channel cross-sectional area to short-term variations in wave activity and tidal volumes, and (4) the distribution of tidal flows within the channel.

It is concluded that: (1) a qualitative correlation exists between short-term channel cross-sectional area change and the ratio of ebb-tidal power to wave power. It is inferred that the important element is the direct wave activity on the ebb-tidal delta; (2) duration differences in rising and falling phases of the tide (flood longer than ebb) lead to an ebb dominance in bed-load capacity at the inlet with the result that this inlet has a natural flushing ability; (3) there is pronounced sand circulation within the inlet complex via a sediment flow loop which is driven by wave refraction and lateral inflow on the updrift side. The sand volumes thus delivered annually to the inlet channel from the ebb delta appear to far exceed the estimated littoral drift. The local sand circulation should, therefore, be considered in engineering design for inlet control structures. (Authors)

020 **BYRNE, R.J., GAMMISCH, R.A., and THOMAS, G.R.** 1980. Tidal prism-inlet area relations for small tidal inlets: Conf. Coas. Engr., 17th, Proc., 2517-2533.

Fourteen tidal inlets within the lower Chesapeake Bay were studied to examine whether significant differences existed in their hydraulic behavior relative to the larger oceanic inlets hitherto studied. Measurements included simultaneous external and internal tides, gaging of discharge through a tidal cycle, measurements of inlet geometry, and basin area. The results indicate that: (a) smaller inlets ($A_c < 100\ m^2$) depart from the relationship between inlet throat area and tidal prism developed for oceanic inlets; (b) examination of inlet width versus depth indicates the departure from ocean inlet geometry occurs at A_c values between 100 and 500 m^2; (c) the maximum velocity in smaller inlets is significantly less than oceanic inlets (~ 0.35 <u>vs</u> 1.0 m/s); (d) tidal phase lags and tidal range ratio were generally equal. However, for conditions of significant tide range reduction, the low water phase lags more closely approximated the tide range ratio. (Authors)

C

021 **CHEN, R.J., and HEMBREE, L.A.** 1977. Comparison of numerical and physical hydraulic models, Masonboro Inlet, North Carolina: GITI Rpt. 6, Appendix 3, Tracor Inc., Austin, Texas, 281 pp.

The purpose of this project was to modify an existing two-dimensional numerical hydrodynamic model to be applied to Masonboro Inlet, North Carolina. The model essentially consists of a numerical solution to the time-dependent linearized shallow-water equations. One of the modifications was the incorporation of tidal flats which are important in the Masbonboro Inlet system. The second was to devise a procedure for handling open water boundaries at which no boundary conditions were available. Using data for September 1969 supplied by CERC, the friction factor was adjusted to simulate the observed tide stage variation and intratidal current phasing. The magnitude of the computed currents were consistently small but this is not thought to seriously delimit the model's utility. (Authors)

022 **COLLINS, D.J.** 1982. Morphology, hydrodynamics and subsurface stratigraphy of an ebb-tidal delta: Indian River Inlet, Delaware: M.S. Thesis, Univ. of Delaware, Newark, Delaware, 222 pp.

Indian River Inlet transects a Holocene transgressive baymouth barrier 21 km to the south of the entrance to Delaware Bay along Delaware's Atlantic coastline. Prior to the stabilization of the inlet in 1938 by the US Army Corps of Engineers, the nearshore was characterized by straight and parallel contours. However, since stabilization a large ebb-tidal delta has been forming seaward of the tips of the inlet jetties. Indian River Inlet forms an ideal location to investigate the development of an ebb-tidal delta due to the controlled nature of the inlet system subsequent to stabilization.

Gross patterns of development of the ebb-tidal delta were investigated by comparing bathymetric charts published by NOAA back to 1954. Shallow penetration, high resolution sparker profiles revealed the morphology, internal stratification, and thickness of the ebb-tidal delta lithosome. Shallow stratigraphy of the study area was determined by the investigation of four vibracores drilled on the ebb-tidal delta. Modern processing acting in the inlet and across the ebb-tidal delta were determined by examining relevant literature, by collecting current meter data of two stations on the ebb-tidal delta, and by collecting drogue data through an ebb flow cycle.

Currents in the nearshore zone of Delaware are partially controlled by flood and ebb currents in Delaware Bay. During flood flow in the bay, nearshore ocean currents are flowing north towards the bay. During ebb flow in the bay, nearshore ocean currents are flowing to the south away from the bay. Times of ebb flow in Delaware Bay and Indian River Inlet are quite close, therefore, the issuing ebb current out of the inlet is deflected to the south, causing preferential sediment transport and deposition to the south of the inlet.

The internal stratification within the ebb-tidal delta sands is dominated by large scale (3 - 6 m in heights) progradational foreset beds. The large scale foreset beds are interpreted as original delta deposits formed by the lateral growth of the ebb-tidal delta with time. Smaller scale sedimentary structures including horizontal stratification and herringbone cross-stratification, and contorted structures form intrasets within the large scale foreset beds.

The prograding foreset beds downlap on a strong seismic reflector, informally named in this study for the predelta surface. The predelta surface separates the ebb-tidal delta sediments from the underlying sedimentary deposits. The predelta surface slopes concave upward offshore at a decreasing angle, leveling off at approximately 13 m below mean low water. The predelta surface is interpreted as corresponding to the ravinement surface which is produced by wave erosion at the shoreface as the baymouth barrier retreats during a transgression. Back barrier/proximal lagoon and lagoonal sedimients underlie the predelta surface.

From the shallow penetration, high resolution sparker profiles, and the vibracores, a model of an ebb-tidal delta in a transgressive setting was developed. The model shows large scale, low angle accretionary foreset bed associated with delta growth dipping radially away from the inlet. Small scale sedimentary structure intrasets are developed within the large scale master bedding. The ebb-tidal delta lithosome disconformably overlies Holocene back barrier/proximal lagoon and lagoonal deposits. The applicability of the generalized model to the ancient rock record is illustrated with an example from the Upper Carboniferous in the Pocahontas Basin of West Virginia. (Author)

023 **COMBE, A.J., and WATTS, G.M.** 1976. Response of Carolina Beach Inlet to a deposition basin dredged in the throat: Special Conference on Dredging and its environment, Eff., Proc. Amer. Soc. Civ. Engr., 719-735.

Tidal inlets change in time as a result of the relationship between the sand (littoral materials) available for transport and the transporting agents (tide and wave-induced currents). Any tidal inlet, influenced by adjacent littoral material movement, is generally in a state of dynamic change, the response being related to waves, currents, and quantity of littoral materials supplied.

Basically, wave-induced currents transport materials alongshore to the inlet. On flood tide, the materials tend to be carried to the interior part of the inlet complex and deposited on the inner bar. On ebb tide some of the materials deposited on the inner bar are transported back seaward and deposited on the ocean bar.

Reasoning that the bar channel over the ocean bar would deepen if the quantity of material available within the inlet for resuspension by ebb tidal currents was reduced by catching the material in a sediment trap, a deposition basin was dredged in the throat of the uncontrolled inlet at Carolina Beach. Optimum use of the dredged material was effected by placing it on the shores downdrift from the inlet. Three dredging cycles and eleven hydrographic surveys have revealed that the inlet responds to the presence of the trap, but a quantitative relationship between deposition basin size and the resulting channel width, depth, and alignment has not been reached. (Authors)

024 **COSTA, S.L.** 1978. Sediment transport dynamics in tidal inlets: Ph.D. Dissertation, Dept. of Oceanog., Univ. of California, San Diego, California, 222 pp.

Various aspects of the dynamics of sediment transport in tidal inlets were investigated based on the assumption that the discharge through the natural inlets includes flows that exceed the condition of the threshold of sediment movement and that the magnitude of sediment transport is intimately related to the power expended on the bed. The anisotropic nature of small fluid velocity perturbations on the magnitude and direction of bed-load transport over a movable rippled bed received particular attention.

Laboratory experiments designed to be free of scale effects were conducted. The effects on sand transport in the channel of a model tidal inlet due to small velocity perturbations were determined for a range of tidal periods, amplitudes, and shapes. The size of the model and the associated tidal prism were also varied. Idealizations inherent in model experiments were investigated.

It was concluded that the dynamics of sediment transport over the bed forms normally associated with tidal inlets is quite different than might be expected. The results of the experiments indicated that, over a significant range of velocities, sediment transport over a movable, rippled bed is proportional to an unexpectedly high power of the flow velocity over the bed. This highly nonlinear expression can be stated succinctly as

$$i \sim v^n, \; n = f(d,D,V)$$

where i is the sediment transport rate, v is the overlying flow velocity, d is the sand grain size, and D is the depth of flow. The exponent, n, is an expression of the transport regime of an inlet and appears to be around 5 for natural inlets in equilibrium. It is clear that such highly nonlinear effects can exist only because the transport of sediment is a small part of the power expanded on the bed. The model experiments were conducted from approximately this regime upward ($n \geq 7$).

An attempt is made to explain this physically unintuitive development by considering observed and deduced details of the flow over such a bed. It is postulated that the flow consists of two interacting flow regimes: a conventional turbulent main flow driving a near-bed flow that has characteristic quasi-ordered vortexlike features. It is apparent that the mean flow conditions, the turbulent fluctuations generated over the bed forms, and the bedform geometry itself, all interest to govern the transport dynamics.

The application to natural tidal inlets is probably widespread, and the scale relation needed to extend model results to full scale is developed with a view toward such application. (Author)

025 **COSTA, S.L., and ISAACS, J.D.** 1975. Anisotropic sand transport in tidal inlets: Sym. on Modeling Techniques, Proc. Amer. Soc. Civ. Engr., 1:254-273.

The occurrence of natural flushing action in tidal inlets has long been recognized. Unfortunately, the natural situation is often inadequate for man's desired uses. The traditional solutions of dredging or the erection of sediment barriers are expensive, of short-term usefulness, and engender a degree of environmental shock. This investigation involves redirecting a small part of the power in tidal flows in a manner as to greatly modify sediment deposition in such inlets. A small unidirectional secondary flow from ocean to bay disproportionately reduces power available to transport sediment into the channel and similarly increases the power available to transport sediment seaward. The results from hydraulic and computer models indicate the small perturbations to the inlet dynamics achieved in this manner have a large nonlinear effect on the overall transport of sediments in the channel. The amount of change is much greater than might be expected from such small changes in the tidal flow.

Recent studies have indicated that model and field data seem to be governed by the same law relating tidal flow and equilibrium channel geometry. Since these are the primary agents governing the results of our experiments, it may be possible to extend the results to real size harbors with substantial meaningfulness. (Authors)

026 **COSTA, S.L., and ISAACS, J.D.** 1977. The modification of sand transport in tidal inlets: Coastal Sediments '77, 5th Sym. of the Waterway, Port, Coastal and Ocean Div., Proc. Amer. Soc. Civ. Engr., 946-965.

This study extends the concepts of sand transport modification in tidal inlets from model experiments to possible field scale applications. The extension is made by appealing to existing data, for both scales, from unidirectional stream and flume flows. The differences between such flows and the tidal flows of inlet channels are recognized. The difficulties in identifying scale effects in general for the two-phase phenomena persist. However, the similarities between the data of different scales yield some cofidence in making qualitative (and probably some quantitative) extensions from model to field scales. The reason for such similarities seem to be a result of interactions between the flow and the various types of bed forms. This extension from model to field scales, although generally of an empirical nature, demonstrates that the sand transport of many natural inlets appears to be governed by fairly high powers of mean channel velocity. Thus, small changes to this velocity, from whatever source, may lead to profound changes in the sand transport characteristics of inlets in both model and field scale systems. (Authors)

027 **COTTER, D.C.** 1974. Tide-induced net discharge in lagoon-inlet systems: M.S. Thesis, Univ. of Miami, 40 pp.

The tide-induced net discharge is determined by solving the system of long wave equations and inlet equations numerically and integrating the discharge over a tidal cycle. The results of the computations show that (1) the net discharge can be of a magnitude that is important when considering the renewal of the waters of the lagoon and (2) the magnitude of the net discharge is strongly affected by the inlet dimensions. The last conclusion suggests that a considerable increase in net discharge can be obtained by properly designing the inlets.

The physics underlying the net discharge is generally obscured when applying numerical techniques to solve the governing equations and therefore an analytical solution is sought to delineate the causes and principles behind the net discharge. Unfortunately, the analytic expression for the net discharge turns out to be rather complicated and therefore does not fulfill part of the purpose of this study, i.e., to gain physical insight and in particular to establish the role of the dimensions of the inlet with respect to the magnitude of the net discharge. In addition, it appears from comparison with numerical results that because of the linearization process applied to the friction term, the analytic solution yields at best an approximate value of the net discharge. For accurate results recourse should be taken to numerical techniques.

Rather than from the analytic solution, physical insight can best be obtained from the equation describing the dynamics of the flow in the lagoon. This equation expresses the balance between the radiation stress and the net bottom stress associated with the long wave traveling in the lagoon-inlet system and the stress associated with the net discharge. Because the net discharge results from the nonlinear term in the governing equations, significant net discharge should only be expected for large values of a/h (a = amplitude h = depth). (Author)

028 **CZERNIAK, M.T.** 1977. Inlet interaction and stability theory verification: Coastal Sediment '77, 5th Sym. of the Waterway, Port, Coas. and Ocean Div., Proc. Amer. Soc. Civ. Engr., 754-773.

Due to a series of happenstance events involving the opening, closing, dredging, and jettying of Moriches and Shinnecock Inlet, New York, and due to the interconnecting nature of their bays, some unique inlet behavior has been observed. This includes the "hydraulically unstable" behavior of Moriches Inlet in both the "scour" and "shoaling" modes, a change with time in the hydraulic stability curve governing the behavior of Moriches Inlet, and evidence of hydraulic interaction between the two inlets as a result of changing bay tidal dynamics. The purpose of this paper is to explain the complex history of Moriches and Shinnecock Inlets in terms of the stability theory presented by O'Brien and Dean (1972). With appropriate extensions, it was found that their stability model qualitatively explained all observed inlet behavior. As such, this case study lends considerable support to the theory by providing some verification to parts of the theory which heretofore appear to have had little support from field studies. (Author)

D

029 **DAVIS, R.A., and FOX, W.T.** 1972. Coastal processes and nearshore sand bars: Jour. Sed. Pet., 42(2):401-412.

Detailed daily topograhic maps of beach and inner nearshore areas indicate a cyclic pattern to processes and responses in this nontidal environment. This pattern is the result of complex interaction between changes in shoreline configuration, discontinuous nearshore sandbars, and environmental variables such as barometric pressure, wind velocity, breaker height, and longshore currents. Of the 18 variables measured, barometric pressure appears to provide the best index for changes in coastal processes. The results of these variations are morphologic changes in the beach and inner nearshore area.

As a low pressure system approaches the coast there is an increase in wind velocity, breaker height, and longshore current velocity as barometric pressure drops. When the low pressure system passes, barometric pressure rises and there is a reversal of wind direction with an accompanying reversal of longshore current direction.

This cycle in conditions is accompanied by a pattern of responses in the position and morphology of the shoreline and sandbars. During high pressure and low energy conditions, shallow discontinuous sandbars have somewhat regularly spaced rip channels. The shoreline is slightly sinuous with protuberances behind the sandbars. Longshore currents are slow and small waves break on the bars causing their shoreward migration. Shoreline sinuosity increases as protuberances grow and embayments are slightly eroded. An approaching low pressure system causes increase in wind, waves, and longshore current velocity. As the pressure system passes there is reversal of longshore current direction at the time of maximum wind velocity and wave height. During this time rapid longshore currents are deflected by the sinuous shoreline such that strong rip currents are formed. These rip currents pass over sandbar crest and excavate channels. At the same time new bars are forming as sediment accumulates in relatively quiet areas between rip channels. As a result there is apparent migration of the bar form. The return to low energy conditions yields a pattern much like that during the previous time of low energy.

In response to these coastal processes, the bar form oscillates back and forth alongshore rather than migrating down the beach, although the sediment does move alongshore. (Authors)

030 **DAVIS, R.A., and FOX, W.T.** 1980. A dynamic process model for the beach-inlet transition zone: Univ. of South Florida, Tampa, Dept. Geol., Rpt. No. TR-3, 68 pp.

Monitoring of tide and wave-generated processes adjacent to Matanzas Inlet, Florida, was conducted during the summer of 1978. Data collected include weather parameters, wave and longshore current measurements, and tidal currents and morphology of the inlet and adjacent beach and nearshore area. Measurements were made in a time-series mode in order to provide desired input for anticipated modeling of inlet mouth dynamics. Related concurrent projects included drogue studies of tidal currents, sediment transport, bed forms, and sediment texture in the inlet. Weather conditions during the study period were typical of summer conditions on the east coast of Florida. Interactions of tidal inlet processes with open coast processes are significant but restricted to only a few hundred meters of coast adjacent to the inlet. Longshore currents act alternately as a reinforcement and as a hindrance to flow as tides flood and ebb. During flood tides flow on the upcurrent side of the inlet is reinforced and the downcurrent side is hindered. Ebb currents produce the opposite effect on the longshore currents. Beyond the terminal lobe of the ebb-tidal delta there is little effect of tidal currents on coastal processes. Inlet morphology is an extremely important influence on tidal processes. During flood conditions flow is controlled by channels until shoals are submerged at which time flow is determined primarily by overall inlet shape. (NTIS Abs.)

031 **DAVIS, R.A., and FOX, W.T.** 1981. Interaction between wave- and tide-generated processes at the mouth of a microtidal estuary. Matanzas River, Florida (U. S. A.): Mar. Geol., 40:49-68.

The zone of transition between the wave-dominated open coast and tide-dominated mouth of estuaries is complicated. A time-series study of wave parameters, longshore currents, and tidal parameters at the mouth of an estuary on the northeast coast of Florida has demonstrated that tidal influence on nearshore processes is modest and localized.

Tidal currents are nearly undetectable less than 0.5 km from the estuary mouth along the open coast. Tidal currents reach 80 cm/s in the throat of the main ebb channel but immediately seaward of the terminal lobe of the ebb delta the tidal component is barely detectable with longshore currents predominating. Lateral flood channels adjacent to the estuary mouth show that tidal currents are significant and dominate longshore currents near low-tide stage, but are suppressed by longshore currents near high tide.

Weather patterns may have an important effect on tidal processes at the estuary mouth because they control wave impingement and therefore longshore current speed and direction. Longshore currents may reinforce or suppress tidal currents, particularly in lateral flood channels. (Authors)

032 **DeALTERIS, J.T.** 1976. A speculative model for the evolution of an island, tidal inlet-lagoon system: I, Regional Analysis (Abs.): Geol. Soc. Amer. Abs., 8(2):156-160.

Recent studies by workers in tidal inlet dynamics have identified a relationship between the morphometric and hydraulic characteristics of a tidal inlet-lagoon system. Distortions to the tidal wave as it progresses through the lagoon system of a tidal inlet regulate the net sediment transport tendency of the tidal inlet. The mechanics of these distortions to the tidal wave are presently being considered. However, the results of the studies reported on to date suggest an evolutionary process in the development of a barrier island tidal inlet-lagoon system. Initially, the hydraulics of a breakthrough inlet on a barrier island spit tend to pump sediment to the lagoon system. As the lagoon fills, fringing tidal marshes develop, deep tidal channels are scoured, and the hydraulics of the inlet evolve to favor net sediment transport out of the lagoon system. Superimposed on this basic model is rising sea level, landward migrating barrier islands, and a shifting of the barrier spit headland in the updrift direction, leaving new shallow lagoons and breakthrough inlets. The resulting coastal geomorphology is similar to that of New Jersey and the Delmarva Peninsula. In fact, the proposed model hypothesizes a developmental scheme applicable to each of the five coastal compartments within the Middle Atlantic Bight, and perhaps, to barrier island coastlines, in general. (Author)

033 **DeALTERIS, J., McKINNEY, T., and RONEY, J.** 1978. Beach Haven and Little Egg Inlets, a case study: Conf. Coas. Engr., 16th, Proc., 1881-1899.

A comprehensive investigation of coastal processes active within and in the vicinity of Beach Haven and Little Egg Inlets was completed as part of the Coastal Processes Investigation for the proposed Atlantic Generating Station. The suspected complex nature of this dual natural inlet system was documented and a process-response model is presented to relate the more significant physical forcing functions to observed morphologic and hydraulic changes. A rising sea level, a net littoral drift from the north, and the sediment scouring power of the flow in the two main channels serving the tidal basins are the principal factors related to the geographic and hydraulic stability of the system. The results of the study can be used to evaluate the potential impact, if any, of the proposed Atlantic Generating Station on the adjacent coastal environment. (Authors)

034 **DEAN, R.G., and PERLIN, M.** 1977. Coastal engineering study of Ocean City Inlet, Maryland: Coastal Sediments '77, 5th Sym. of the Waterway, Port, Coas. and Ocean Div., Proc. Amer. Soc. Civ. Engr., 520-542.

The paper includes a discussion of the causes of shoaling in the main channel at Ocean City Inlet, Maryland. Since construction of the jetties in 1934-1935, the shoreline immediately north of the inlet has advanced approximately 800 ft, and the shoreline south of the inlet has receded a distance of 1,700 ft. It is suggested that the cause for shoaling of the inlet channel and erosion of the southern shore is the low and permeable south jetty which allows sand transport northward into the inlet. Sand carried past the south jetty is moved westward by wave action and deposited on the northwestern shore of Assateague Island. Ebb-tidal currents and waves then transport the material into the channel where deposition and shoaling occur. The authors recommended that conditions be improved by increasing the elevation of the south jetty and rendering it sand tight. (Fields)

035 **DEFEHR, K.J., and SORENSON, R.M.** 1973. A field investigation of the hydraulics and stability of Corpus Christi Water Exchange Pass, Texas: Coas. Hyd. and Ocean Engr. Group, Texas A&M Univ., College Station, Texas, 125 pp.

A field study was conducted at Corpus Christi Water Exchange Pass, an artificial tidal inlet connecting the southeast corner of Corpus Christi Bay, Texas, with the Gulf of Mexico. The objectives of this study were to determine: (1) the hydraulic characteristics of the inlet, (2) its response to various physical processes, and (3) the nature of its stability. Field work included current measurements, collection and analysis of sediment samples, and measurements of tidal fluctuations in the inlet and Corpus Christi Bay. Hydrographic data were obtained from a concurrent hydrographic study of Corpus Christi Water Exchange Pass conducted by University of Texas personnel. Tidal data for the Gulf of Mexico and Corpus Christi Bay provided by the Galveston District Corps of Engineers, and weather data provided by the National Oceanic Administration were analyzed along with the field data. The inlet has experienced shoaling in the vicinity of the gulf and bay mouths since its completion in August 1972. Erosion of the bay shoreline near the inlet has occurred. A designed channel bend is partially responsible for erosion of the south bank of the inlet. Wind setup, induced by the passage of cold fronts, influences flow velocities. (Authors).

036 **DENNIS, W.A., and DALRYMPLE, R.A.** 1978. A coastal engineering analysis of Roosevelt Inlet, Lewes, Delaware: Univ. of Delaware, College of Mar. Studies, Sea Grant Tech. Rpt. No. DEL-SG-4-78, 194 pp.

The presence of Roosevelt Inlet has caused significant erosion problems at Lewes Beach, Delaware. Furthermore, the deteriorated condition of the steel sheet-pile jetties has allowed excessive shoaling to occur in the inlet.

Historical material was collected for the proper analysis of these problems consisting of: a complete history of the connecting waterways prior to the initial excavation of Roosevelt Inlet in 1937, an analysis of shoreline changes in the vicinity of the inlet both before and after stabilization, comparison of historic hydrographic charts resulting in estimates of shoaling rates and the identification of trends in changing inlet dimensions, and a compilation of dredging and beach nourishment histories for the inlet and Lewes Beach, respectively.

To examine the present littoral and hydraulic processes ongoing in the vicinity of the inlet, four field studies were conducted. These studies resulted in complete surveys of both the offshore and inlet bathymetries, comparative beach profiles along 1,000-ft sections of both adjacent beaches, a sand tracer study, and current and tide measurements--within the inlet throat as well as in the Lewes and Rehoboth Canal.

A numerical model was developed encompassing the connecting waterways from Roosevelt Inlet to Indian River Inlet. The model was used to investigate the hydraulic and stability characteristics of Roosevelt Inlet. A major result of the model is a prediction of a mean southerly pumping of water throughout the entire system. The effect of this mean flow through Roosevelt Inlet was found to significantly enhance its tendency to shoal.

Results of this study indicate that sand should be periodically bypassed in order to help alleviate the erosion at Lewes Beach. This may be accomplished in conjunction with the maintenance dredging of the inlet channel. The results also indicate that the inlet should be redesigned, decreasing the jetty width from 500 to approximately 350 ft, resulting in a deeper and more maintenance-free navigation channel. Furthermore, it may be advantageous to incorporate a low-sill weir section at the shoreward end of the updrift (west) jetty allowing sand to spill over the weir into a depositional area, thus becoming readily available for bypassing. (Authors)

037 **DENNIS, W.A., LANAN, G.A., and DALYRMPLE, R.A.** 1978. Case Studies of Delaware's Tidal Inlets. Roosevelt and Indian River Inlets: Conf. Coas. Engr., 16th, Proc., 1282-1301.

Studies were undertaken to document the past and present characteristics and trends of Delaware's two major tidal inlets, Roosevelt and Indian River Inlets.

It was found that both inlet complexes are effective sediment traps causing considerable downdrift erosion. The major mechanism by which sand enters Indian River Inlet is by overtopping the impounded south jetty. At Roosevelt Inlet sediments are readily transported past the several steel sheet-pile jetties.

The results of a one-dimensional hydraulic model, as well as field measurements, predict the presence of a mean southerly flow through the canal and bay system which connects these two inlets. This flow is shown to have a substantial effect on the behavior and stability of these entranceways, causing major asymmetries on the depositional patterns at each locations. Roosevelt Inlet was found to have a strong tendency to trap sediment within its throat; whereas, Indian River Inlet, on the opposite end of the system, was found to retain large quantities of sand on its developing ebb-tidal shoal. (Authors)

038 **DOLAN, R., and GLASSEN, R.** 1973. Oregon Inlet, N. C. A History of Coastal Changes: Southeastern Geographer, XIII(1):41-53.

The paper includes a brief description of the history of Oregon Inlet, North Carolina. The temporal responses of Oregon Inlet to the major inlet-shaping processes are discussed in terms of how their interaction results in specific inlet configurations. (Fields)

039 **DRUERY, B. M., and NIELSEN, A.F.** 1980. Mechanisms operating at a jettied river entrance: Conf. Coas. Engr., 17th, Proc., 2607-2626.

Between October 1976 and July 1977 a northern rubble-mound jetty was constructed at the mouth of the Hastings River, transforming the entrance from a single to a double jettied system. Prior to the jetty consti :tion the entrance was characterised by the presence of a substantial swash bar (alternatively called an ebb-delta marginal shoal) which was a continuous feature over 100 years of hydrographic survey records. However, construction of the northern jetty triggered an unprecedented onshore movement of the swash bar. This movement was well documented by a field monitoring program incorporating hydrosurveys, aerial photographs, tidal gaugings, sediment sampling, float tracking, and nearby wave rider buoy information.

A semiquantitative model was developed to aid understanding and quantification of the macrosedimentary process associated with this phenomenon. The model demonstrated that the sudden reduction of the swash bar was due to the disruption of a circulation of sand which had previously aided the dynamic stability of the bar. The quantitative predictions of the model agreed well with subsequent entrance behavior. The philosophical development of the model and its findings are discussed in detail.

In the literature there is a general lack of attempts to quantify the sediment transport relationships between the gross morphologic features of tidal entrances. This paper presents a methodology for assessing the sedimentary process at tidal entrances. (Authors)

E

040 **EBERHARDT, J.M.** 1978. Erosion at Amity Point; An example of shoreline recession in a Tidal Inlet, Orme, G.R., and Day, R.W., eds., Handbook of Recent Geological Studies of Moreton Bay, Brisbane River, and North Stradbroke Island: Dept. of Geol., Queensland Univ., Paper 8:2, 82-88.

Erosion at Amity Point on North Stradbroke Island is related to the eastward migration of Rainbow Channel resulting from the realignment of South Passage to a North-South orientation. Available survey records, aerial photographs, and recent research document this change. Slumping of the channel banks occurs and erosion is greatest where Rainbow Channel is closest to the shore. Rock groins constructed since 1972 have interrupted the southward movement of beach sediment thereby increasing erosion. (Author)

041 **ESCOFFIER, F.F.** 1977. Hydraulics and Stability of Tidal Inlets: GITI Report 13, US Army Corps of Engineers, Coas. Engr. Res. Cen., Ft. Belvoir, Virginia, 75 pp.

This report presents a summary of several of the important basic developments pertaining to analysis of the hydraulics and related stability of tidal inlets. In particular, it covers the work reported by Brown (1928) and Keulegan (1967) on inlet hydraulic calculations, and by O'Brien (1931, 1966), Jarrett (1976), Bruun (1966), Johnson (1973), O'Brien and Dean (1972), and Escoffier (1940) on the analysis of inlet channel stability. The original inlet stability concept proposed by Escoffier is extended in light of recent work. The report also contains brief discussions on tidal characteristics and functional design requirements as well as case studies of selected inlets on the US coasts. (Author)

042 **ESCOFFIER, E.F., and WALTON, T.L.** 1979. Inlet stability solutions for tributary inflow: Jour. Waterway, Port, Coas. and Ocean Div., Proc., Amer. Soc. Civ. Engr., 105(4):341-355.

Formulas in use relating to the flow of water through tidal inlets do not as a rule take into account two factors, inertia and tributary inflow, which probably play a significant role in determining the characteristics of many inlets. These two factors--the inertia of the water as it flows through the inlet and the tributary inflow to the bay that causes ebb flow through the inlet to exceed flood flow--are considered in a solution proposed herein.
The solution method applies to inlets that have a bay in which the water rises and falls uniformly over the entire bay area. An additional assumption is that the discharge into and from the inlet is governed by head loss that is quadratic in the velocity. (Authors)

043 **EVERTS, C.H.** 1977. Self-maintaining navigation channels for certain enclosed harbors: Proc. 4th Int. Conf. on Port and Ocean Engr. Under Arctic Conditions, Memorial Univ., St. John's Univ., Newfoundland, Canada, 382-393.

A method of predicting the stable configuration of a navigation channel connecting open tidal waters with an enclosed harbor is presented. Using data from the harbor of Dillingham, Alaska, and rivers near Anchorage, Alaska, a relationsnip between stable cross-sectional area, cross-sectional shape, bottom elevation, and water discharge has been determined. The best fit linear equation to the data collected from these sites is:

$$A = 0.56Q^{0.52}$$

where: A = cross-sectional area (m^2)
Q = total discharge through the channel during an ebb cycle (m^3)

The relationship appears to be useful in the design of self-maintaining navigation channels cut through sediments similar to those on northern tidal flats (highly compacted glacial silt and mud-sized material generally lacking in clay minerals and organic constituents). (Fields)

044 **EVERTS, C.H.** 1980. A method to predict the stable geometry of a channel connecting an enclosed harbor and navigable waters: US Army Corps of Engineers, Coas. Engr. Res. Cen., Tech. Paper No. 80-6, 18 p.

A method if presented to predict the stable configuration of a navigation channel connecting open tidal waters with an enclosed harbor. The stable cross-sectional area, cross-sectional shape, and bottom elevation of the channel are considered. A relationship between these variables and the water discharge through the channel is determined using the geometric characteristics of nearby natural channels and the hydraulic regimes that sustain the channels. Using appropriate field data, the method may be applied to the design of a navigation channel in any region where natural tidewater drainage or river channels exist.

An example is given using data obtained from a navigation channel at the harbor of Dillingham, Alaska, and from natural drainage channels on a tidal flat and in rivers near Anchorage, Alaska. The resulting relationship (tidal prism/channel cross section) may be used when sediments are like those on northern tidal flats, i.e., highly compacted glacial silt and mud-sized material generally lacking in clay materials and organic constituents. (Author)

F

045 **FARMER, R.C., and WALDROP, W.R.** 1977. A model for sediment transport and delta formation: Coastal Sediments '77, 5th Sym. of the Waterway, Port, Coas. and Ocean Div., Proc. Amer. Soc. Civ. Engr., 102-115.

A mathematical technique is described for the analysis of the deposition of suspended material in flowing streams. One critical feature of any such technique which is included in this model is the necessity of adequately predicting the three-dimensional flow patterns which transport the suspended material. Calculation of the movement and deposition of suspended material was accomplished by solving a sediment species continuity equation which permitted the suspended material to convect and diffuse with the fluid. This computation required specifying a settling velocity, turbulent diffusion rate, scour rate, and reflection rate for the bottom for several classes of particle sizes. It was necessary to recompute the flow field periodically because the deposition and scour constantly modified the bottom topography.

The computational procedure was applied to deltaic formation in the vicinity of a crevasse of a river near the sea. An actual simulation was not attempted because the diffusion, reflection, and scour rates could not be defined with sufficient accuracy to provide meaningful results. However, the effects of the main factors believed to influence deltaic growth were parametrically investigated. The results indicated deposition patterns offshore from the river mouth which are consistent with field observations. (Authors)

046 **FINLEY, R.J.** 1975. Inlet shoal and shoreline development in relation to seasonal wave energy flux, North Inlet, South Carolina (Abs.): Geol. Soc. Amer. Abs., 7(7):1073.

Surf zone wave observations during a year of quarterly studies at North Inlet, S. C., have documented a pattern of dominantly southward wave energy flux (P_{1s}). Four stations were monitored, two on either side of the inlet, and the station just downdrift of the inlet was found to lie within a zone of energy flux reversal due to wave refraction around the ebb-tidal delta. As a result, longshore transport of sediment is directed toward the inlet from both sides adding to swash bars, the channel-margin linear bars, and building a northward recurving spit since the inlet stabilized in its present position in the 1930's.

Comparison of volumetric changes in the ebb-tidal delta between 1925 and 1965 yields an estimated annual rate of increase of $4.1 \times 10^5 m^3$ ($5.5 \times 10^5 yd^3$). Resultant annual longshore energy flux vectors of 16.02 kg-m/sec/m (35.3 ft-lb/sec/ft) at the most updrift station and 12.84 kg-m/sec/m (28.3 ft-lb/sec/ft) in the zone of reversal give a derived inlet-directed longshore sediment transport rate (Q) of $3.5 \times 10^5 m^3$/yr, utilizing the design relationship $Q = (7.5 \times 10^3)\ P_{1s}$. This value is 83 percent of the annual longshore transport rate derived from volumetric change, indicating that shoal growth over several tens years may be used to give an indication of the longshore energy flux which would be derived from littoral process measurements. (Author)

047 **FINLEY, R.J.** 1975. Morphologic development and dynamic processes at a Barrier Island Inlet, North Inlet, South Carolina, Ph.D. Dissertation, Univ. of South Carolina, 269 pp.

Detailed quarterly studies at North Inlet, South Carolina, have shown variation in wave parameters, beach and inlet morphology, and tidal hydraulics which are related to seasonal climate patterns. Wind magnitude and direction, occurrence of northeast storms, and brackish water influx from adjacent Winyuah Bay are significant process variables. Over 2,400 littoral process observations indicate that annual resultant wave energy flux is directed to the south. An energy flux reversal due to ebb-tidal delta morphology, however, results in longshore transport of sediment toward the inlet, adding to swash bars, the channel-margin linear bars, and a northward recurving spit. An estimate of the volume of inlet-directed longshore sediment transport ($3.5 \times 10^5 m^3/yr$) based on observed energy fluxes gives a value which is 83 percent of the annual longshore transport rate ($4.1 \times 10^5 m^3/yr$ based on 39 years of spit and shoal growth.

Beach profiles at eleven locations have shown that erosion is primarily due to northeast storms and that the shoreline is transgressive. A maximum of 7 m of foredune retreat was observed during the winter of 1972-73, contributing abundant sediment to the ebb-tidal delta, which has a present volume of over 35,700,000 m^3. The only beach not severely eroding lies immediately south of the inlet inlet where the ebb-tidal delta affords protection from northeast storm wave approach, and onshore migration of swash bars provides sediment to the longshore transport reversal.

The southern channel-margin linear bar of the ebb-tidal delta has increased in width and length during recovery from the February 1973, northeast storm. Reduction in cross-sectional area of the inlet throat during the fall and winter months is related to sediment added to the northern channel-margin linear bar. The flood-tidal delta is migrating westward under the influence of wave seiche at high tide and is being dissected by ebb flow from a minor tidal creek.

Hydrographic observation over complete spring mean, and neap tidal cycles have been used to determine volume of the tidal prism, examine current velocity distributions, and determine coefficients of friction and repletion. prism volume varies from 7.43×10^6 to $25.52 \times 10^6 m^3$, depending on tidal phase and meteorological influences, with a mean of $14.96 \times 10^6 m^3$. Maximum tidal current velocities reach 120 cm/sec and time-velocity asymmetry is present. Average Manning's "n" friction coefficients have been found to range from 0.032 to 0.041, with extremely high and low values around slack water as a result of variation in tidal flow and water level elevation. Keulegan repletion coefficients are applicable to tidal flow at North Inlet, with certain conditions, despite the complex nature of flow into a marsh-filled area and the hydraulic connection to adjacent Winyah Bay. (Author)

048 **FINLEY, R.J.** 1976. Hydraulics and dynamics of North Inlet, South Carolina, 1974-75: GITI Report 10, US Army Corps of Engineers, Coas. Engr. Res. Cen., Belvoir, Virginia, 188 pp.

Quarterly studies at North Inlet, S. C., show variation in wave parameters, beach and inlet morphology, and tidal hydraulics which are related to seasonal climatic patterns. Wind magnitude and direction, occurrence of northeast storms, and brackish water influx from adjacent Winyah Bay are significant process variables. Over 800 unique visual wave observations indicate that annual resultant wave energy flux is directed to the south. However, an energy flux reversal resulting from ebb-tidal delta morphology results in longshore transport of sediment toward the inlet, adding to swash bars, the channel-margin linear bars, and northward recurving spit. An estimate of the volume of inlet-directed longshore sediment transport ($3.5 \times 10^5 m^3/yr$) based on observed energy fluxes, gives a value which is 83 percent of the annual longshore transport rate ($4.3 \times 10^5 m^3/yr$) based on 39 years of pit and shoal growth. Beach profiles at 11 locations show that erosion is primarily due to northeast storms, and that the shoreline is transgressive. A maximum of 7 m of foredune retreat was observed during the winter of 1972-73, contributing abundant sediment to the ebb-tidal delta, which has a present volume of over 35,700,000 m^3. The only beach not severely eroded lies immediately south of the inlet, where the ebb-tidal delta affords protection from northeast storm wave approach, and onshore migration of swash bars provides sediment to the longshore transport reversal. The southern channel-margin linear bar of the ebb-tidal delta has increased in width and length during recovery from the February 1973 northeast storm. Reduction in the cross-sectional area of the inlet throat during the fall and winter months is related to sediment added to the northern channel-margin linear bar. The flood tidal delta is migrating westward under the influence of waves at high tide, and is being dissected by ebb flow from a minor tidal creek. Hydrographic observations over complete spring, mean, and neap tidal cycles were used to determine the volume of the tidal prism, to examine current velocity distributions, and to determine coefficients of friction and repletion. Prism volume varies from $7.43 \times 10^6 m^3$ to $25.52 \times 10^6 m^3$ depending upon tidal phase and meteorological influences, with a mean of $14.96 \times 10^6 m^3$. Maximum tidal current velocities reach 120 cm/sec and time-velocity asymmetry is present. Average Manning's n friction coefficients were found to range from 0.032 to 0.041. Keulegan repletion coefficients are applicable to tidal flow at North Inlet, despite the complex nature of flow into a marsh-filled area and the hydraulic connection to adjacent Winyah Bay. The two major channels must be considered separately, and extreme values of n which coincide with slack water must be excluded from any analyses. (Author)

049 **FINLEY, R.J.** 1978. Ebb-tidal delta morphology and sediment supply in relation to seasonal wave energy flux, North Inlet, South Carolina: Jour. Sed. Pet., 48(1):227-238.

A close relationship has been found between wave energy, longshore sediment supply, and the ebb-tidal delta morphology of North Inlet, South Carolina. Surf zone wave observations during seasonal studies have documented a pattern of dominantly southward wave energy flux, as expressed by the longshore energy flux factor (P_{ls}). Four stations were monitored, two on either side of the inlet, and the station just downdrift of the inlet was found to lie within a zone of energy flux reversal due to wave refraction around the ebb-tidal delta. Since the inlet stabilized in its present position in the 1930's, longshore sediment transport has been directed toward the inlet from both sides, building up the ebb-tidal delta.

Comparison of volumetric changes in the ebb-tidal delta between 1925 and 1964 yields an estimated annual rate of accretion of $4.33 \times 10^3 m^3$ (5.66 ×

$10^3 yd^3$). Net annual longshore energy flux factors of 157.0 joule/sec/m (35.3 ft-lb/sec/ft) at the most updrift station and 128.1 joule/sec/m (28.8 ft-lbs/sec/ft) in the zone of transport reversal indicate an inlet-directed longshore sediment transport rate (Q) of $3.53 \times 10^3 m^3$/yr ($4.6 \times 10^3 yd^3$) utilizing the design relationship $Q = 7.5 \times 10^3) P_{1s}$. This value is 82 percent of the ebb-tidal delta accretion rate, indicating that the primary source of sediment for the ebb-tidal delta is the longshore transport system and that the ebb-tidal delta is an efficient trap for littoral drift. Low-intensity northeast storms, while contributing to beach erosion, may have an accretionary effect on the ebb-tidal delta by activating the sediment transport reversal. (Author)

050 **FINLEY, R.J., and HUMPHRIES, S.M.** 1976. Morphologic development of North Inlet, South Carolina, Hayes, M.O., and Kana, T.W., eds., Terrigenous Clastic Depositional Environments: Coas. Res. Div., Dept. of Geol., Univ. of South Carolina, Tech. Rpt. II-CRD, II-172-II-184.

Coastal processes studies at North Inlet, South Carolina, have shown variation in wave energy and beach inlet morphology which are related to seasonal climatic patterns. Northeast storms result in southward sediment transport, hence barrier spit growth to the south occurred between 1925 and 1939. Severe beach erosion accompanies these storms. Much of the sand eroded from updrift beaches has contributed to ebb-tidal delta growth since inlet stabilization in 1939.

Measurements of wave energy flux during seasonal field observations revealed an energy flux reversal due to ebb-tidal morphology. This results in transport of sediment toward the inlet adding to swash bars, the channel-margin linear bars, and a northward recurving spit in the area just south of the inlet. An estimate of the total volume of inlet-directed longshore sediment transport ($3.5 \times 10^5 m^3$/yr), based on observed energy fluxes, gives a value which is about 82 percent of the annual longshore transport rate ($4.3 \times 10^5 m^3$/yr) based on spit and shoal growth between 1925 and 1964. These data suggest that longshore sediment transport is the primary source of sediment for the ebb-tidal delta, and that these shoals are an efficient trap for littoral drift in the stage of development following inlet stabilization. (Authors)

051 **FITZGERALD, D.M.** 1976. Ebb-Tidal delta of Price Inlet, South Carolina, Geomorphology, physical processes and associated inlet shoreline changes, Hayes, M.O., and Kana T. W., eds., Terrigenous Depositional Environments: Coas. Res. Div., Dept. of Geol., Univ. of South Carolina, Tech. Rpt. II-CRD, II-143-II-157.

The ebb-tidal delta of Price Inlet is a multicomponent system which continually responds to a changing wave climate and varying tidal range. The channels have dominant flow directions and are floored by unidirectional bed forms. Swash bars develop on the seaward portion of the delta, migrate landward and attach to the channel-margin linear bars, forming swash bar-channel-margin linear bar complexes. Over the past three years, these bar complexes have increased in size; the southern bar complex has migrated landward while the northern one has remained stable.

Linear and cuspate megaripples predominate on the surface of the seaward and interior portions of the bar complexes. The landward orientation of these features is caused by wave bores which retard ebb currents but which augment flood currents. The flood dominance of this area is also due, in part, to the high bar surface on the landward portion of the channel-margin linear bar, which shields the seaward portion of the bar complex from ebb-tidal currents. Trenches through the southern bar complex show a dominance of large to small scale, landward dipping, tabular crossbeds produced by the landward migration of swash bars, megaripples, and the bar complex frontal slipface. Plane bedding, which is a result of sheet flow deposition, is also common.

During the early history of Price Inlet, its shoreline was molded by normal inlet migration processes. Recurved spit growth prograded the northern shoreline while contemporaneous erosion occurred on the southern side of the inlet. Sometime between 1661 and 1856, Price Creek breached the southern spit system of Bulls Islands, and the inlet became stabilized. Since that time, the southern shoreline of the inlet has been affected by landward migration of bar complexes and a sediment transport reversal process. Changes on the northern side of the inlet have been a result of landward bar migrations and spit growth. Erosional events on either side of the inlet occur when the ebb-tidal delta is asymmetric to one side or the other, leaving the opposite side of the inlet exposed to storm waves. (Author)

052 **FITZGERALD, D.M.** 1977. Hydraulics, morphology and sediment transport at Price Inlet, South Carolina: Ph.D. Dissertation, Univ. of South Carolina, 96 pp.

A sand circulation pattern has been determined for Price Inlet, South Carolina, using wave refraction diagrams, littoral process measurements, bed-form orientations and inlet hydraulic data. The dominant process acting on the ebb-tidal delta is wave swash which impedes the ebb-tidal currents and augments the flood-tidal currents. This produces a net landward transport of sand on the ebb-tidal delta as evidenced by the landward migrating swash bars. Bed-form orientations and velocity measurements taken on the swash bars also support this conclusion.

Countering the general landward transport direction is the ebb dominance of the main channel. This dominance can be explained by higher inlet efficiency at low water than at high water. Consequently, bay tide phase lag is larger at high than at low water resulting in a longer flood duration. This causes higher mean ebb-tidal currents and a consequent larger potential net ebb transport of sand. This inlet characteristic explains why the throat remains scoured and why sand entering the main channel is carried seaward.

The ebb-tidal delta of Price Inlet is a multicomponent system which continually responds to a changing wave climate and varying tidal range. The channels have dominant flow directions and are floored by unidirectional bed forms. Swash bars develop on the seaward portion of the delta, migrate landward and attach to the channel-margin linear bars, forming swash bar-channel-margin linear bar complexes. Over the past three years, these bar complexes have increased in size; the southern bar complex has migrated landward while the northern one has remained stable.

Linear and cuspate megaripples predominate on the surface of the seaward and interior portions of the bar complexes. The landward orientation of these features is caused by wave bores which retard ebb currents but which augment flood currents. The flood dominance of this area is also due, in part, to the high bar surface on the landward portion of the channel-margin linear bar, which shields the seaward portion of the bar complex from ebb-tidal currents. Trenches through the southern bar complex show a dominance of large to small scale, landward dipping, tabular crossbeds produced by the landward migration of swash bars, megaripples, and the bar complex frontal slipface. Plane bedding which is a result of sheet flow deposition is also common.

During the early history of Price Inlet, its shoreline was molded by normal inlet migration processes. Recurved spit growth prograded the northern shoreline while contemporaneous erosion occurred on the southern side of the inlet. Sometime between 1661 and 1856, Price Creek breached the southern spit system of Bulls Island, and the inlet became stabilized. Since that time, the southern shoreline of the inlet has been affected by landward migration of bar complexes and a sediment transport reversal process. Changes on the northern side of the inlet have been a result of landward bar migrations and spit growth. Erosional events on either side of the inlet occur when the ebb-tidal delta is asymmetric to one side or the other, leaving the opposite side of the inlet exposed to storm waves.

A 2.5-year study (July 1974 to January 1976) of Price Inlet, South Carolina, was designed to determine the inlet hydraulics, channel morphology, and processes affecting changes in the inlet throat cross section. The most important hydraulic characteristic of the inlet is the ebb dominance of the main channel. The steep channel banks of the inlet throat coupled with a substantial increase in bay area during the flooding cycle produce a longer flood duration than ebb duration. This results in stronger maximum and time-averaged ebb current velocities and causes a potential net sediment transport in a seaward direction through the inlet throat. The inlet ebb dominance is evidenced by megaripples and sand waves on the floor of the channel that remain ebb oriented throughout the tidal cycle.

Tidal currents have scoured a relatively deep and narrow inlet with a maximum channel depth of 8.5 m and throat width of 200 m. The asymmetric inlet profile is thought to be the result of the dominant southerly longshore transport direction, the close location of the northern marginal flood channel to the inlet throat and, most importantly, the pattern of the channel thalweg. During the study period of a dextral rotation of the inlet opening through the ebb-tidal delta is believed to have been caused by the preferential formation of swash bars by dominant northeasterly waves or alternatively, the seaward growth of the ebb-tidal delta and a consequent deflection of ebb flow in the main channel.

Sequential inlet cross sections indicate that the throat responds rapidly to changing flow conditions and more slowly to longer term changes in ebb-tidal delta morphology. Short-term changes of up to 10 percent of the 1,150 m^2 mean cross-sectional area can occur due to concentrated erosion or deposition of a spit which extends southward into the inlet from Bulls Island to the north. The spit grows in response to the southerly transport of sand through the northern marignal flood channel and along the beach; it retreats due to the erosive power of the flood- and ebb-tidal currents. During the period of investigation, the supply of sand to the throat section was significantly reduced because of shoaling and narrowing of the northern marginal flood channel. This was caused by the substantial growth of the ebb-tidal delta and resulted in a 13 percent increase in the average throat cross-sectional area. These short- and long-term changes in throat cross-sectional area observed at Price Inlet may explain deviations of some of the inlets from the tidal prism-cross-sectional area curves obtained by O'Brien and others. (Author)

053 **FITZGERALD, D.M.** 1979. Accretional shoreline processes at tidal inlets along South Carolina Coast (Abs.): Bull. Amer. Assoc. Pet. Geol., 63(3):451 pp.

The greatest shoreline changes of barrier islands along the South Carolina coast occur in the vicinity of tidal inlets. Depositional processes at these inlets can be categorized as those associated with (1) migrating inlets, (2) stable inlets, and (3) inlets whose main ebb channels breach new positions through their ebb-tidal deltas.

At migrating inlets, curved beach ridges are added to the updrift island while the downdrift island erodes. These processes occur most commonly at shallow inlets whose main ebb channels do not scour into the marine or lagoonal muds underlying the barrier-island sands. Shoreline breachings during storms are also important at inlets with histories of rapid migrations.

Stable inlets have deeper main ebb channels which are entrenched in resistant clays. Morphologic changes associated with these inlets are predominantly the result of wave processes. The coalescing of wave-build swash bars in the outer part of the ebb-tidal delta and the subsequent landward migration of these bar complexes can cause inlets to have either a downdrift or updrift offset, or a straight configuration.

The well-developed ebb-tidal deltas of the South Carolina inlets normally have a single main ebb channel and two or more marginal flood channels. The dominant northeast wave approach causes southerly longshore transport of sand along most of the South Carolina coast and a preferential addition of sediment to the north side of the ebb-tidal delta, which results in a northerly migration of the outer part of the main ebb channel. Because the southerly course is longer and less efficient than a straight course through the ebb-tidal delta, the main channel eventually breaches a new position through a northern marginal flood channel. The accumulation of sand which flanked the old channel is transported landward and accretes to the downdrift beach. (Author)

054 **FITZGERALD, D. M.** 1982. Sediment bypassing at mixed energy tidal inlets: Conf. Coas. Engr., 18th Proc., 1094-1118.

Inlet sediment bypassing, through the previously recognized mechanisms of stable inlet processes and ebb-tidal delta breaching, has been documented at six mixed energy (tide-dominated) coasts around the world including the coasts of: central South Carolina, Virginia, southern New Jersey, New England, the East Frisian Islands, and the Cooper River Delta in Alaska. Regardless of the mechanism, the end product of the bypassing process is the formation of a large bar complex that migrates onshore and attaches to the downdrift inlet shoreline. Thus sediment bypassing is a discontinuous process at mixed energy tidal inlets.

The morphology of the bar complexes is highly variable with widths ranging from 40-300 m and lengths from 300 to over 1,500 m. Generally, the size of the bar complexes increases as inlet size increases and as the rate of longshore sediment transport increases. The frequency of bar welding events at mixed energy inlets varies from 3-7 years. The location where the bars attach to the downdrift beach and length of shoreline that is affected by the bar welding process is dependent on inlet size, orientation of the main ebb channel, and wave versus tide dominance of the shoreline. (Author)

055 **FITZGERALD, D.M., FICO, C., and HAYES, M.O.** 1979. Effects of the Charleston Harbor, S. C., jetty construction on local accretion and erosion: Coastal Structures '79, Proc. Amer. Soc. Civ. Engr., 641-664.

The stabilization of a tidal inlet interrupts the natural sediment transport patterns of the ebb-tidal delta and adjacent beaches. The resulting erosional-depositional changes to both onshore and offshore areas are caused by an adjustment of this sytem to new hydraulic and wave energy conditions.

The morphological changes which have occurred due to jetty construction at Charleston Harbor, S. C., have been caused by the redirection of the main ebb-channel; the confinement of the ebb-tidal currents to the jettied channel causing the transport of sand to the deeper waters; the prevention of natural sediment bypassing mechanisms and a redistribution of wave energy and tidal currents.

The ebb-tidal delta and adjacent beaches have responded to these conditions by adding sediment to the updrift barrier and offshore region, accelerating the erosion of the downdrift barrier, and redistributing the ebb-tidal delta sediments to the old channel location and to the barrier island systems to the south. A substantial amount of sediment was deposited in the offshore region downdrift of jetties between 1921 and 1965. The source of this accretion is believed to be sand that has been transported seaward through a secondary ebb-channel located next to the jettied channel. (Authors)

056 **FITZGERALD, D.M. and FITZGERALD, S.A.** Factors influencing tidal inlet throat geometry: Coastal Sediments '77, 5th Sym. of the Waterway, Port, Coas. and Ocean Div., Proc. Amer. Soc. Civ. Engr., 563-581.

Tidal inlets along depositional coasts exhibit diverse throat cross sections due to varying physical processes and geologic histories. The relative importance of tidal energy and wave regime greatly affects the geometry of inlet throats. On the Georgia coast, tidal ranges greater than 1.5 m-2.0 m produce large tidal prisms and flow areas. The inlets on this coast generally have average depths of greater than 7 m. In contrast, inlets are relatively shallow along coasts which are dominated by wave processes. Average depths of inlets in North Carolina, Florida, and the Gulf Coast are less than 6 m, for example.

A study of central South Carolina inlets has shown that the symmetry of the inlet throat is related to three controlling factors: (1) the meandering of the channel thalweg, (2) the shoreline configuration, and (3) the dominant longshore transport direction. The sedimentological nature of the inlet throat can also have an important influence on its geometry.

During the past century, most of these inlets have narrowed and deepened due to spit accretion on both sides of the inlet. Changes in their flow areas through the time are attributed in part to the filling in of the marshes and also to the construction of the Intracoastal Waterway, which changed the drainage area of the system.

Cross-sectional profile data from Price Inlet, S. C., over a 3-year period from July 1974 to July 1977, and an in-depth study on 29 June 1977, indicate that the inlet responds quickly to changing flow conditions and more slowly to changes in the ebb-tidal delta. A good correlation has been found between inlet throat cross-sectional area and the flood tidal range directly preceding the running of the cross-sectional profiles. (Authors)

057 **FITZGERALD, D.M., HUBBARD, D.K., and NUMMEDAL, D.** 1978. Shoreline changes associated with tidal inlets along the South Carolina coast: Coastal Zone '78, Proc. Amer. Soc. Civ. Engr., 1973-1994.

Tidal inlet processes can have a profound effect on the morphology of adjacent barrier beaches. Inlet associated shoreline changes have been studied with the aid of sequential vertical aerial photographs, hydrographic charts, and field investigations at several inlets on the South Carolina coast. These studies have provided a basis of classifying inlet shoreline changes into three major categories: (1) those associated with migrating inlets; (2) those associated with inlets whose main ebb channels breach new positions through the ebb-tidal delta; and (3) those associated with stable inlets.

Inlet migration, which is related to the addition of curved beach ridges to the updrift island, is most important at shallow inlets where the main channel does not scour into the more resistant marine or lagoonal muds underlying the barrier island sands. Shoreline breaching during storms is also important in inlets with histories of rapid migration. Often, the two mechanisms are interrelated, as at Kiawah River Inlet, S. C. Between 1922 and 1939, the inlet migrated 1.3 km southward by spit accretion and subsequently breached 1 km to the north during a large storm on October 15, 1947.

The well developed ebb-tidal deltas associated with South Carolina inlets normally have a single main ebb channel and two marginal flood channels. The dominant northeast wave approach along the South Carolina coast causes a southerly transport of sand and preferential addition of sediment to the north side of the ebb-tidal delta. This results in a southerly migration of the outer portion of the main ebb channel. Because of the southerly course is longer and leff efficient than a straight course through the ebb-tidal delta, the main channel eventually occupies the position of the northern marginal flood channel. The accumulation of sand which flanked the old channel migrates landward and welds onto the downdrift beach. These bars are typically 0.5-3.0 km long on the South Carolina coast.

Shoreline changes associated with stable inlets are a result of wave generated sediment transport. Recurved spits building from the updrift barriers have narrowed many of the South Carolina inlets over the past 100 years. The coalescing of wave-built swash bars in the outer portion of the ebb-tidal delta and the subsequent landward migration of these bar complexes can cause inlets to have either a downdrift offset, an updrift offset, or a straight configuration. Erosion of these shorelines seems to occur when the ebb-tidal delta is asymmetric and overlaps one side of the inlet shoreline preferentially, leaving the other side exposed to storm waves. (Authors)

058 **FITZGERALD, D. M., and LEVIN, D.R.** 1981. Hydraulics, morphology and sediment transport patterns at Pamet River Inlet: Trur, Mass., Northeastern Geol., 3:216-224.

Pamet River Inlet, which is located along northern Cape Cod Bay, was stabilized in 1919 by the construction of two rock jetties. Prior to stabilization, the inlet had a history of northward migration with periodic breaching of the spit to the south. This process coupled with an abundant sediment supply, derived from cliff erosion to the south, resulted in a number of parallel beach ridges separated by old channel positions along the inlet's northern shoreline.

The historical filling of the back barrier environment has been primarily caused by the building of dikes across portions of the marsh and sand deposition along the bay's southern shoreline and on the flood-tidal delta. Sand is transported into the bay by bar migrations along the shallow southern side of the jettied channel and through the marginal channel landward of the north jetty. The decrease in bay area has lessened the inlet's tidal prism which in turn has caused a decrease in the inlet's cross-sectional area.

Initially, jetty construction caused a progradation of the inlet's southern shoreline and retreat of the shoreline to the north. Through time this pattern of sedimentation has rendered the south jetty ineffective and has caused a detachment of the north jetty from the adjacent dune ridge. Presently, the inlet shorelines are more stable due to active inlet sediment bypassing. The shallow ebb-tidal delta swash platform permits wave sediment transport past the jetties and a nourishment of the beach to the north. Landward migrating swash bars north of the jetties are evidence of this process. (Authors)

059 **FITZGERALD, D.M., LINCOLN, J.V., and FINK, L.K.** 1984. Hydraulic character of Maine's tidal inlets (Abs.), Geol. Soc. Amer. Abs., 16(1):16.

On the mesotidal coast of Maine small to medium sized inlets (width <200 m) have stronger flood than ebb-tidal current velocities (10-20 cm/s at the inlet throat). The flood dominance of these inlets results from a flood duration that is 2-5 hr shorter than the ebb phase. This hydraulic characteristic is in contrast to the other mesotidal inlet along the Atlantic Coast with similar physical settings.

The flood dominance of Maine's inlets is controlled by factors outside of the inlet including (1) the shallow depth of the ebb-tidal delta and spit platform and (2) a shoaling of the tidal wave. The shallow nature of the ebb-tidal leads to a confinement of the ebb currents late in the ebb cycle. When the tide changes the inertia of the ebb flow must be overcome by the rising tide before water can enter the inlet. The high profile of the swash platform prevents flood waters from moving into the inlet peripherally. Consequently, the flood cycle is delayed and shortened.

The response of the tidal wave as it propagates into the Gulf of Maine also causes an asymmetry in tidal phase. As the tidal wave shoals across the Gulf it steepens in a manner similar to a wind-generated wave close to shore. This results in a shorter period in the rise of the tide than the fall of the tide. Along the southern Maine coast this difference can be as much as 28 min.

The flood dominance of Maine's small- to medimum-sized inlets causes a net transport of sand into the back barrier. This process has resulted in the formation of large flood-tidal deltas and sand clogged channels. (Authors)

060 **FITZGERALD, D.M., and NUMMEDAL, D.** 1980. Ebb-tidal delta stratification and its relation to tidal inlet processes (Abs.): Bull. Amer. Assoc. Pet. Geol., 64(5):707 pp.

Shallow, high resolution seismic reflection profiles at nine tidal inlets along the South Carolina coast have shown that ebb-tidal delta stratification is dominated by small to large-scale accretionary beds associated with channel cutting and infilling sequences. The deeper parts of the ebb-tidal delta (15 to 25 m) are comprised chiefly of shallow-landward and seaward-dipping beds (3 to 5 deg) and horizontal stratification. These beds represent initial sedimentation in large channel-fill sequences and original delta deposits. At intermediate depths (5 to 15 m) the stratification is dominated by large-scale (2 to 5 m in height) multidirectionally dipping accretionary beds (3 to 15 deg) that were formed owing to channel migration. Small channel cut and fill deposits are also prevalent at this depth. The upper delta is characterized by laterally continuous landward-dipping foresets formed by landward-migrating swash bars. Because of the depth of the ebb-tidal delta sediments (25-30 m), their preservation through a transgression appears likely.

The development of this stratification is caused by a southerly migration of the inlet's main ebb channel through the ebb-tidal delta sediments. Eventually, the channel becomes hydraulically inefficient and a new channel is breached through a spillover lobe to the north. The abandoned channel is then filled with sediment that is derived from seawash sand shoals which flanked the old main ebb channel and with sand that is transported seaward in the new main ebb channel. The landward transport of sand which causes an infilling of the abandoned channel and a southerly migration of the main ebb channel is the result of accretion through bed-load sediment transport and landward-migrating swash bars. (Authors)

061 **FITZGERALD, D.M., NUMMEDAL, D., and KANA, T.W.** 1977. Sand circulation pattern at Price Inlet, South Carolina: Conf. Coas. Engr., 15th, Proc., 1868-1880.

Wave refraction diagrams, littoral process measurements, bed-form orientations and inlet hydraulic data were used to determine sand circulation patterns for Price Inlet, South Carolina. Data collected on the ebb-tidal delta indicate dominant landward transport of material in the form of migrating swash bars. Along the seaward edge of the delta, southerly transport occurs. The main inlet channel, however, demonstrates a net transport of sand. This is attributed to a greater inlet efficiency at low water than high water, and consequently a longer flood duration. This in turn causes higher mean ebb-tidal currents in the main channel.

The quantity of sediment transport was determined by an equation from Maddock (1969), in which the total sediment transport rate is proportional to the cube of the current velocity. A potential net ebb transport rate of 364,000 tons per year was calculated for the inlet throat. Comparing this with a net longshore transport rate of 128,000 tons per year suggests that the potential net ebb discharge of material is capable of removing longshore drift and keeping the channel scoured. (Fields)

062 **FITZGERALD, D.M., NUMMEDAL, D., and PENLAND, S.** 1984. Sedimentation processes along the East Frisian Islands, West Germany: Conf. Coas. Engr., 19th, Proc., 396-397.

The East Frisian Islands are located on a high wave energy, high tide range shoreline where the average deepwater significant wave height exceeds 1.0 m and the spring tidal range varies from 2.7 m at Juist to 2.9 m at Wangerooge. This island chain, unlike many throughout the world that are eroding due to the eustatic rise in sea level, has undergone accretion during the past 300 years. The patterns of erosion and deposition along the islands are related to the location and mechanisms of inlet sediment bypassing and directions of longshore sediment transport. This paper will discuss the factors that influence these processes. (Authors)

0063 **FLOYD, D.** 1976. The result of river mouth training on the Clarence River Bar, N.S.W., Aust.: Conf. Coas. Engr., 15th, Proc., 1738-1755.

A case study is given of river training works at the mouth of the Clarence River. The study spans a period of ninety years. Extensive hydrographic data from the later part of this period is presented and examined in detail.

Prior to 1903 internal training walls had been constructed to stabilize the internal channel and stabilize the bar location at the mouth of Clarence River. In 1956 construction started on entrance jetties with the aim of deepening the bar. The work was carried out over a period of 16 years. The slow rate of construction has allowed changes in bar depth to be compared with depths estimated by an empirical formula which relates bar depth to tidal flow and channel width. Results have shown that the empirical formula gives a reasonable estimate of bar depths and that bar depth is independent of jetty length.

Results have shown that the behavior of the bar is strongly affected by floods. Some details of bar volume and movement are presented. (Author)

064 **FORMAN, J.W., and MACHEMEHL, J.L.** 1978. Sediment dynamics and shoreline response at Drum Inlet, North Carolina: UNC Sea Grant College Program, Working Paper 78-2, 159 pp.

A study of Drum Inlet was conducted to develop a hypothesis of sediment movement at the inlet, to determine the stability and predict the future of the inlet, to determine the response of the barrier island to the presence of the inlet, and to develop a sediment budget and establish shoaling rates for the inlet and flood tidal shoals.

Aerial photographs (October 1971 to March 1977) of the inlet and adjacent barrier islands were analyzed to determine the volume of shoreline erosion and accretion of the barrier island occurring during the study period, the patterns and rates of growth of the flood tidal shoals, and the movement rates of primary bed forms across the flood tidal shoals.

A flourescent tracer study was conducted in August 1977 to determine the rates and patterns of sediment movement in high and low energy zones at the inlet. The maximum ebb and flood current velocities and the current directions were measured in the inlet main channel, distributary channels, and at selected points in the low energy shallow shoals area. Sediment core samples from eight locations at varying distances from the inlet mouth were analyzed to determine grain size distributions of the inlet sediments.

Correlation of aerial photographs and field data revealed a pattern of sediment circulation in the inlet. It was found that the inlet mouth and adjacent beaches served as sources of sediment moving in and out of the inlet system. The sediments from the inlet mouth and the head of the flood tidal delta moved across the shallow flood-current dominated shoal areas into ebb dominated distributary channels where it was recirculated back to the inlet mouth.

It was found that the presence of the inlet caused severe erosion of 1.5 miles of shoreline adjacent to the inlet mouth. Nodal points, 3,000 ft south of the inlet center line and 5,000 ft north of the inlet center line, were found. The nodal points were characterized by little change in beach position compared to other points in the study area. The overall net shoreline erosion that occurred during the study period was 5.5 million cu yd.

The sediment budget analysis which considered the contributions of littoral drift, beach erosion, sediment trapping, and bypassing provided an order of magnitude value of the shoaling rate. It was found that approximately 13 percent of the material supplied to the inlet was trapped on the shoals. This volume rate of shoaling amounted to 360,000 cu yd/year. This value was in close agreement with the calculated volume of material on the shoals.

The stability of the inlet was determined by comparing rates and patterns of growth of inlet features and by calculating the ratio of tidal prism to littoral drift volume proposed by Bruun and Gerritsen (1960) and Bruun (1966). By the end of the study period the beaches, inlet throat, and flood tidal shoals had reached a relatively stable configuration. This implied that there was substantial flushing of littoral material from the inlet. From these analyses and a ratio of tidal prism to littoral drift volume equal to 23 ($\Omega/M < 100$ indicates poor stability), it was determined that the inlet stability was fair and that shoaling would continue at a rate much less than in the early life of the inlet. (Authors)

065 **FOX, W.T., and DAVIS, R.A.** 1981. Tidal and longshore current interference patterns at Matanzas Inlet, Florida: Northeastern, Geol., 3:306-317.

The interaction of tidal currents and wave-generated currents produced asymmetrical tidal deltas at Matanzas Inlet, Florida. During July and August, waves and current in vicinity of the inlet were monitored with moored current meters, drogue flow meters, and electromagnetic meters.

The Eulerian current data from the moored meters and Lagrangian data from the current drogues were combined to form a 12-stage model for currents in the inlet. When the wave-generated current was from the south, the flood current flowed in along the south flood channel and a null line of divergence formed along the north shore. With a south wave-generated current, the ebb current moved out along the north shore with a null line of convergence on the south shore. When the wave-generated current is from the north, the null lines shift to the opposite side of the inlet and the current patterns develop in a mirror image. The null lines mark the areas of sediment accumulation which form marginal swash bars. With the dominant wave-generated currents from the south, the ebb-tidal delta is asymmetrical with the ebb channel pointing to the northeast. (Authors)

G

066 **GALLIVAN, L.B., and DAVIS, R.A.** 1981. Sediment transport in a microtidal estuary: Matanzas River, Florida (USA): Mar. Geol., 40:69-83.

Tidal channels and shoals at the mouth of the Matanzas River are the site of considerable sediment transport. Rates and patterns of transport were determined using fluorescent dyed sediment tracers which were introduced on three intertidal locations. Temporal sampling after introduction was at the surface and by coring. Transport rates and patterns were examined for both quartz and shell hash fragments in the distinctly bimodal sediment. Wave activity and time-velocity asymmetry of currents produced a net landward sediment transport over the channel-margin bar and flood delta. The combination of time-velocity asymmetry and deflection of currents by the ebb shield causes landward transport over the flood delta. Ebb transport of sediment dominates in the south flood channel. Minimum sediment transport rates vary with morphology, currents, and grain-size parameters, but these rates average 15-20 m over one tidal cycle. Wave activity enhances transport of shell hash. Vertical variation in tracer concentration consistently decreases with depth. Depth of disturbance values are typically 10-15 cm on the channel margin bar, but are variable elsewhere, being controlled by type and height of bed forms. (Authors)

067 **GALVIN, C.** 1982. Shoaling with bypassing for channels at Tidal Inlets: Conf. Coas. Engr., 18th, Proc., 496-1513.

A channel dredged at the mouth of a tidal inlet is subject to rapid shoaling because of longshore transport, but this shoaling is slower than would be computed from simple trapping of all the moving littoral drift. The reduction in shoaling rate is due to the bypassing of littoral drift which occurs simultaneously with shoaling. This report presents a systematic method for computing the rate of shoaling in channels subject to shoaling with bypassing. The method also permits estimates of the effect of the dredged channel on the downdrift beaches. (Author)

068 **GOLE, C.V., TARAPORE, Z.S., BRAHME, S.B., and PURANDARE, U.V.** 1975, Dynamic behavior of coastal inlets: Proc. Int. Assoc. for Hyd. Res., 16th Congr., 1:201-207.

Present methods used for predicting the behavior of coastal inlets are confined to what are called stable inlets. Some inlets, however, show a tendency toward sudden closure and sudden enlargement due to variation in littoral drift and freshwater discharge and criteria established on the basis of stable inlets are no longer valid. A study of the dynamics of coastal inlets was therefore undertaken. This method involves assessment of the quantities of siltation and erosion in various zones around the inlet by studying the velocity field caused by flood and ebb tides and alongshore littoral currents. With this method, the seasonal behavior of coastal inlets can be examined. (Comedex Abs.)

069 **GOPALAKRISHNAN, T.C., and MACHEMEHL, J.L.** 1978. Numerical flow model for an Atlantic Coast Barrier Island Tidal Inlet: North Carolina State University at Raleigh, Cen. of Mar. and Coas. Studies, Rpt. No. UNC-SG-78-02, 64 pp.

A numerical model for computation of flow in inlets with junction is developed. The Galerkin technique is coupled with a finite element analysis in the flow model. The vertically integrated equations of momentum and mass conservation (Leendertse 1967) are used with appropriate boundary and initial conditions. The junction conditions are introduced by the time rates of change of energy and mass flux at the junction. A "double sweep" approach is used in solving for the dynamics of flow. A parabolic shape funtion is adopted in the model to satisfy the requirement of linear independence.

The numerical flow model is verified with field data obtained from the US Army Corps of Engineers (1976) for Carolina Beach Inlet, North Carolina. The US Army Corps of Engineers collected tide and current data in the inlet gorge and Atlantic Intracoastal Waterway in November 1974. The tidal fluctuations in the inlet gorge and tidal velocities in the Atlantic Intracoastal Waterway were used as initial and boundary conditions, respectively. The tidal velocities in the inlet gorge and tidal fluctuations in the Atlantic Intracoastal Waterways were computed with the numerical simulation flow model and compared with field data. The Galerkin finite element flow model performed well considering the complex nature of flow in a tidal inlet. (Authors)

070 **GOPALAKRISHNAN, T.C., and MACHEMEHL, J.L.** 1980. Boundary conditions for analysis of flow in tidal inlets: Conf. Coas. Engr., 17th, Proc., 2595-2606.

A method for supplying downstream boundary condition in the absence of measured data for any given forcing function has been developed. This method is based on nondimensional numbers which govern the dynamics of flow. These numbers were determined by a simple application of the II = Theorem to the dynamic parameters of flow.

The above method was applied to the Carolina Beach Inlet, N. C., analysis. The method yields values which are in good agreement to the measured tide and the two points considered. This, no doubt, depends on the numerical method of analysis also. The nondimensional numbers can be used to yield the downstream boundary conditions for any numerical method chosen to analyze the flow provided $\partial U/\partial t$ is the downstream condition needed for all time. If it is $\partial \eta/\partial t$ a different set of nondimensional numbers is required.

The advantage of the method developed here is that one can know the response of a channel system to a hypothetical but possible forcing function for which measured downstream values are not available. This situation is especially relevant to power canals and inlet channels where the flow is affected by man-made alterations in river discharge or construction, etc. (Authors)

071 **GREENWOOD, B., and KEAY, P.A.** 1979. Morphology and dynamics of a barrier island breach: A Study in Stability: Can. Jour. of Earth Sci., 16(8):1533-1546.

A small barrier breach in Kouchibouguac Bay, New Brunswick, is examined with respect to: (a) origin, (b) morphological development, and (c) hydraulic characteristics. The small tidal inlet was formed in 1970 by storm conditions which have a return period of between 5 and 12 years, based upon two different storm intensity indices. Barrier breaching is not a catastrophic event in the temporal sense in the bay and the return period of the initiating storm conditions is close to the average interval between breaching episodes for this barrier system. A threshold barrier morphology is suggested as a more important variable than storm magnitude. Traced from its inception to closure (a period of 6 years), the barrier breach cited revealed: (a) flood domination generating a transfer of large volumes of sedimentary material from the littoral drift system into the lagoon, (b) gradual reduction in tidal prism associated with flood delta growth and infilling of tidal channels, and (c) migration (30 m $year^{-1}$) and increasing reorientation of the inlet neck under a strong preferred littoral drift direction. (Authors)

H

072 **HALES, L.Z., and HERBICH, J.B.** 1973. Tidal inlet current-ocean wave interaction: Conf. Coas. Engr., 13th, Proc., 669-688.

An experimental study was conducted in a three-dimensional wave basin to investigate the manner in which surface gravity waves propagating toward a tidal inlet are altered. Dimensional analysis of the pertinent variables indicates that a functional relationship exists between as many as five dimensionless terms, and the functional relationship is displayed in graphical nondimensional form to apply to all scales. Results indicate the ebb current increases the steepness in the ocean region to such an extent that the wave begins to lose energy by the crest spilling down the front of the wave, and the wave characteristics in the inlet proper may never reach the breaking limit unless factors other than a current alone are involved. (Authors)

073 **HARLEY, R.B., and DEAN, R.G.** 1982. Channel shoaling prediction: A method and application: Conf. Coas. Engr., 18th, Proc., 119-1219.

Due to concerns of possible shoaling problems, an extensive field survey program was carried out at the site of the proposed Cerrejon coal port on the Caribbean coast of northeast Colombia. The program yielded considerable data on winds, waves, currents, and sediment factors. Techniques for the primary measurement of sedimentation-related tendency included dredged test pits, scour crosses, and suspended sediment samplers.

The port plan includes dredging a 4.6-km-long channel varying from 12 to 21 m in depth. In order to assess the magnitude of maintenance dredging and related problems, a method was developed for incorporating the sediment response measurements into predictions of the areal and seasonal distributions of bed load and suspended sediment deposition.

Offshore test pits were monitored for rate of filling and character of the material being deposited. Suspended sediment samplers were similarly observed and also provided data on concentration versus depth.

The procedure which was developed for analysis and interpretation of the data included extrapolation of suspended sediment data to the seabed, investigation of correlations between wind activity and deposition rates, application of test pit data to a channel of larger dimensions, and testing of hypotheses regarding transport mechanisms. The procedure concluded that average annual shoaling would be approximately 300,000 m^3 and predicted areal and seasonal variation of deposition rates. (Authors)

074 **HARRIS, D.L., and BODINE, B.R.** 1977. Comparison of numerical and physical hydraulic models, Masonboro Inlet, North Carolina: GITI Rpt. 6, US Army Corps of Engineers, Coas. Engr., Res. Cen., Fort Belvoir, Virginia, 198 pp.

Four models of Masonboro Inlet, North Carolina, have been developed in a program for assessing the value of models in investigating coastal inlet hydraulics problems. A distorted scale, fixed-bed physical model, a lumped parameter numerical model, and two-dimensional numerical models were included in this study.

Hydrodynamic equations which describe the two-dimensional flow in tidal inlets are developed in an appendix to this report. The Navier-Stokes equations are integrated vertically and time-averaged to form the governing equations for two-dimensional flow. This procedure eliminates a great deal of unnecessary detail about small-scale motions but retains terms descriptive of the interactions between small- and large-scale flow.

Equations are used to investigate the correspondence between model flows. This analysis shows that it should be possible to simulate the major aspects of tidal flow about equally well with either physical or numerical models, that physical models should be most useful for investigating the interaction of the flow of primary importance with boundary conditions or with flows of smaller scale, and that numerical models should be most useful for investigating the interaction between the flow of primary importance and larger scale or external phenomena such as the effects of storms and of the earth's rotation. The assumptions employed in the derivation of the equations used with the lumped parameter model were found to be more restrictive in applications than originally supposed. New equations are presented which display these assumptions more clearly.

A comparison of experimental results obtained with a physical model and calculations made with numerical models with the prototype records shows that, in general, the models simulate tidal height more satisfactorily than tidal current. Results obtained with one of the two-dimensional numerical models were much inferior to the results obtained with the other. The basic design of both two-dimensional numerical models was similar, but there were many subtle differences, indicating that a clear understanding of the modeling process is essential to success in modeling tidal flows. (Authors)

075 **HARRISON, W., KRUMBEIN, W.C., and WILSON, W.** 1965. Model of Sedimentation at an inlet channel: Geol. Soc. Amer., Special Paper 82, 85-86.

The model of sedimentation at an inlet entrance deals with the distribution of mean particle size (M_z) and degree of sorting (S_o) in response to the forces exerted by the wave, longshore-current, and ebb-tidal-current systems at the mouth of a controlled inlet. It is based upon theoretical considerations of sediment transport, upon observations of scale-model and natural inlets reported in the literature, and upon trend-surface analysis of M_z and S_o values from samples taken in the vicinity of an appropriate natural inlet.

The model predicts that the largest particle sizes and the best sorting will occur in the region where the longshore and inlet currents intersect, that sorting will be poorest just seaward of this intersection (and thereby seaward of the breaker zone), that M_z will decrease and S_o will improve in directions of decreasing velocity gradients beyond the breaker zone, and that particles of relatively small diameter which originate in the inlet current will be deposited upon a surface of normally sized and sorted beach sands on either side of the outflowing current. These predictions are tested and confirmed by analysis of weak trends for M_z and S_o shown on residual maps for cubic trend surfaces for the regions flanking the inlet outflow.

It is possible to objectively delimit the boundary, estimate the magnitude, and describe the pattern of inlet influence on M_z or S_o by subtracting the cubic trend surface for the area of the inlet entrance from the cubic trends surface for the unimodified beach. (Authors)

076 **HARTMAN, G.L.** 1977. Jetty effects at the Siuslaw and Rogue Rivers: Coastal Sediments '77, 5th Sym. of the Waterway, Port, Coas. and Ocean Div., Proc. Amer. Soc. Civ. Engr., 287-304.

The paper reviews the histories of the Rogue River and Siuslaw River navigation projects on the Oregon coast. A comparison of the shoaling patterns at the two entrance systems is provided. A brief discussion of the simplified shoaling rate method developed by the Navigation Division of the Portland District is also included. The method is based on empirical information from past surveys and dredging records, and is used to predict controlling dimensions in the navigation channel which result from different dredging efforts at different times and depths. Results from the simplified shoaling rate method are given for the Rogue and Siuslaw River projects. (Fields)

077 **HAYES, M.O.** 1973. Morphology of sand accumulation in estuaries: An introduction to the symposium: Proc. 2d Int. Estuarine Res. Conf., Columbia, S. C., 3-22.

The morphology of sand deposits in estuaries is determined by the interaction of a number of process variables, including: (a) tidal range, (b) tidal currents, (c) wave conditions, and (d) storm action. Of these, variations in tidal range have the broadest effect in determining large-scale differences in the morphology of sand accumulation. The papers in this symposium have, therefore, been arranged according to differences in tidal range of the areas discussed, following the classification scheme proposed by Davies (4):

I. Coarse-grained sediment accumulation in estuaries with small tide ranges (microtidal estuaries: tidal range (T.R.) = 0-2 m).

Wave action and storm deposition are more important in this class than in any other. Galveston Bay, Texas, is an example of this type of estuary.

II. Coarse-grained sediment accumulation in estuaries with intermediate tidal ranges (mesotidal: T.R. = 2-4 m).

Tidal deltas and tidal-current-formed sand bodies increase noticeably in this class. The estuaries of New England, South Carolina, and Georgia are prototypes.

III. Coarse-grained sediment accumulation in estuaries with large tidal ranges (macrotidal: T.R. > 4 m).

Funnel-shaped, wide-mouthed estuaries that contain linear sand bodies are the most common types occurring in this category. Prototypes are Bristol Bay, Alaska, and the Ord River estuary, Australia.

IV. Wide-mouthed estuaries.

This category was created in order to include in the symposium papers covering the large entrances into such major bodies of water as the Baltic Sea and Chesapeake Bay.

Much of the emphasis in these papers has been placed on estuaries in the mesotidal category, principally because these are the ones that have been studied most. Despite the fact that mesotidal estuaries show a wide range in morphological and hydrographic characteristics, the sand shoals affiliated with them are remarkably similar from place to place. For example, flood-tidal deltas usually contain the same major components, including a flood ramp, flood channels, ebb shields, ebb spits, and spillover lobes, regardless of the variations in current and wave conditions under which they occur. Similarly, the ebb-tidal deltas, although they are exposed to great variations in open-ocean-wave intensity, are strikingly consistent in morphology. (Author)

078 **HAYES, M.O.** 1977. Development of Kiawah Island, South Carolina: Coastal Sediments '77, 5th Sym. of the Waterway, Port, Coastal and Ocean Div., Proc. Amer. Soc. Civ. Engr., 828-842.

Kiawah Island, a sparsely populated barrier island near Charleston, South Carolina, was purchased in 1972 by the country of Kuwait for investment purposes. A study of the ecology and coastal processes of the island preceded its development, which began in 1975. Areas of ecological "sensitivity" and those nearshore areas in danger of erosion by waves are not being developed under the present scheme. Thus, the island may serve as a model for future development, should the present plan succeed.

The morphological components of Kiawah Island can be grouped into 4 major subdivisions: (1) an actively changing beach zone, (2) the three tidal inlets of the Stono, Kiawah, and Edisto Rivers, (3) the interior of the island, which is primarily beach-ridge complexes, and (4) the salt marsh-tidal channel area that surrounds the landward portion of the barrier.

The island has been highly modified on either end by the migration of the tidal inlets and their associated ebb-tidal deltas, which determine wave-refraction and tidal-current patterns. These processes mold the shape of the island into an arcuate "drumstick" pattern, which has a bulbous, updrift end composed primarily of bifurcating beach ridges, a relatively narrow central zone of closely spaced multiple beach ridges, and a downdrift recurved spit system. Historical studies using maps, charts, and aerial photographs show shoreline progradation on the east end of over 1,300 m in the past century and the westward building of the recurved spit system at a rate of 40 m/yr since 1949. Minor morphological features such as "cat-eye" ponds (lenticular-shaped ponds located between the bifurcating ridges) are formed as inlet migrations cause rapid changes in patterns of beach-ridge deposition. The tidal deltas act as giant storage systems that feed sediment to the island. (Author)

079 **HAYES, M.O.** 1980. General morphology and sediment patterns in tidal inlets: Sed. Geol. 26:139-156.

Tidal-inlet sediments make up a significant portion of most barrier island complexes. Inlet-affiliated sedimentary units usually include an ebb-tidal delta (seaward shoal), a flood-tidal delta (landward shoal), and inlet-fill sequences created by inlet migration and recurved spit growth.

The morphological components of ebb-tidal deltas include a main ebb channel flanked by linear bars on either side and a terminal sand lobe at the seaward end. This channel is bordered by a platform of sand dominated by swash bars which are separated from adjacent barrier beaches by marginal flood channels. The ebb-delta sand body is coarser grained than other sedimentary units of the inlet and contains polymodal cross-bedding with a slight ebb dominance.

Flood-tidal deltas consist of a flood ramp and bifurcating flood channels on the seaward side, which are dominated by flood currents and flood-oriented sand waves, and ebb shields, ebb spits, and spillover lobes on the landward side, which contain an abundance of ebb-oriented bed forms. A proposed stratigraphic sequence for a typical flood-tidal delta contains bidirectional, large-scale cross-bedded sand at the base, predominantly large-scale (flood-oriented) cross-bedded sand in the middle, and finer grained tidal flat and marsh sediment at the top.

Inlets migrate at rates that vary from a few to several tens of meters per year, depending upon such variables as rate of longshore sediment transport and depth of the inlet. Inlet-fill sequences, which fine upward, contain coarse, bidirectional cross-bedded sediments at the base, polydirectional cross-bedded sands in the middle, and fine-grained aeolian sand at the top.

Both tidal-delta morphology and relative size and abundance of ebb- and flood-tidal deltas are considerably different in different oceanographic settings. Microtidal (tidal range (T.R.) = 0-2 m) areas tend to have smaller ebb-tidal deltas and larger flood-tidal deltas; whereas, mesotidal (T.R. = 2-4 m) areas show just the opposite trend. Large waves tend to inhibit the development of ebb-tidal deltas and accentuate the growth of flood-tidal deltas. (Author)

080 **HAYES, M.O., KANA, T.W., and BARWIS, J.H.** 1980. Soft designs for coastal protection at Seabrook Island, S. C.: Conf. Coas. Engr., 17th, Proc., 897-912.

To gain a better understanding of the cycles of shoreline changes on Seabrook Island, South Carolina, and advise a private developer on how to deal with localized erosion problems, a detailed field survey and historical study were completed. The data base included historical charts dating from 1661, vertical aerial photographs from 1939, field surveys of beach profiles and nearshore bathymetry over a six-month period, and sediment cores through the entire Holocene section. Seabrook Island, less than 6 km in length, is bounded by tidal inlets with extensive seaward shoals. With a 2-m tidal range for the area, changing exposure and orientation of the shoals over time has had a profound effect on the adjacent shoreline of Seabrook Island. Historical evidence points to the importance of offshore shoals which act as natural breakwaters and sediment storage systems. At various times in recent history, these shoals have supplied sediment to Seabrook beaches by means of bypassing mechanisms around tidal inlets. On the other hand, migration of shoals has allowed excess wave energy to strike portions of the shore causing local erosion. Along a portion of the shoreline, short-term erosion is jeopardizing the development. Based on the present study, a set of "soft" engineering designs was proposed which attempt to manipulate offshore sand bodies in a way that will be beneficial to the development and preserve the inherent beauty of the shoreline. Remedial measures recommended for the developer included dredging new inlet channels and construction of a breakwater in the position of a former protective shoal. (Authors)

081 **HUBBARD, D.K.** 1976. Changes in inlet offset due to stabilization: Conf. Coas. Engr., 15th, Proc., 1812-1823.

Available evidence indicates southward littoral transport through the Merrimack Embayment. In apparent contradiction, the beach on the southern (Plum Island) side of the inlet has built seaward of the updrift beach. This phenomenon is related to a balance between storm and fair weather conditions. Wave observations under a variety of surf conditions show, that during storms, sand is transported southward along the face of the nearshore bar fronting Plum Island. During calm periods sand is moved northward along the beach until it is trapped by the southern jetty and removed from the then active tidal current transfer system. Using discharge data and wave measurements from the Merrimack Inlet area, Bruun's bypassing coefficient ($r = Q_{1s}/Q_{max}$, where Q_{1s} is the longshore transport rate in M^3/yr and Q_{max} is the maximum inlet discharge in M^3/sec) was computed for storm and fair weather conditions. During storms, the bar bypassing observed in the field was clearly indicated. During calmer periods tidal current transfer was predicted. This relationship is considered only an approximation as it does not consider many important physical parameters (grain size, nearshore slope, wave type, etc.). (Author)

082 **HUBBARD, D.K.** 1977. Variations in tidal inlet morphology and processes in the Georgia Embayment: Ph. D. Dissertation, Dept. of Geol., Univ. of South Carolina, Columbia, South Carolina, 90 pp.

A study was conducted to describe morphologic variability in tidal inlets along the southeastern coast of the United States. Large-scale sand body distributions were determined by aerial reconnaissance and inspection of oblique and vertical aerial photographs. The distribution of surface bed forms and internal sedimentary structures was determined through low tide ground reconnaissance, SCUBA observations, fathometer profiles, trenches, and box cores.

Based on these studies, three types of inlets were identified: tide-dominated, wave-dominated and transitional. Tide-dominated inlets are characterized by a deep, ebb-dominant main channel flanked by long, linear channel margin bars. Flood-tidal deltas are poorly developed or nonexistent. Sand bodies landward of the inlet throat are confined to tidal point bars further back in the marsh creek system. Wave-dominated inlets are characterized by large, lobate flood-tidal deltas building into wide, open lagoons. The ebb-tidal delta is small and extends only a short distance from the beach. Tidal channels are generally shallow (less than 6 m) and often bifurcate landward and seaward of the throat. Transitional inlets typically concentrate major sand bodies in the inlet throat. Being in a zone of transition, these inlets vary in morphology, depending on whether waves or tidal currents are the more dominant process.

Inlet morphology responds to a number of physical parameters, primarily wave energy and tidal regime. Other factors (tidal prism, inlet cross-sectional area and shape, the nature of the back-barrier bay, the degree of flood or ebb dominance, freshwater input, relative changes in sea level and sediment supply) exhibit lesser controls on inlet morphology.

As inlet morphology and sand body distribution vary through the study area, so would the sequence of sedimentary structures deposited by each inlet type. In a vertical section through a tide-dominated inlet, a lag would form the base of the sequence. This would be overlain by bidirectional trough cross-beds from the deep channel and ebb-oriented, planar, and trough cross-beds from the shallow channel. The sequence would be topped by swash-generated, horizontal flat beds or slightly inclined accretion beds formed along the channel margins. In a wave-dominated inlet sequence, the lower portion would be dominated by landward-oriented planar and trough cross-beds from the shallower channel bottom. The upper section would be dominated by horizontal or slightly inclined flat beds from the shallow channel sides. Transitional inlets would produce a variety of sequences, the exact nature of which would reflect the relative importance of waves and tides. (Author)

083 **HUBBARD, D.K., BARWIS, J.H., and NUMMEDAL, D.** 1977. Sediment transport in four South Carolina Inlets: Coastal Sediments '77, 5th Sym. of the Waterway, Port, Coastal and Ocean Div., Proc. Amer. Soc. Civ. Engr., 582-601.

Hydrographic studies were conducted at four South Carolina tidal inlets to identify zones of active landward and seaward transport, and to document the processes responsible for this dominance. Currents and tidal elevations were monitored for 25 hr at each inlet during varying tidal phases. At Murrells Inlet, wave observations and suspended sediment measurements were made along the wide bar extending obliquely across the throat section. These measurements were used to assess the contributions of wave-induced sediment transport to the system.

Studies indicate that South Carolina inlets are partitioned such that the main channel is ebb dominant, while upper bar surfaces are dominated by landward flow, as described by Hayes et al. (1973). Furthermore, the ebb dominance of the current flow through the throat is more a function of the degree of marsh development in the back-barrier lagoon than the shape of the inlet cross section.

Landward transport on upper bar surfaces can be affected in two ways. First, inlet morphology or time-velocity asymmetry can result in landward flow dominance (and therefore sediment transport) over the shoal. Alternately, flood currents can reduce shoaling effects on incoming waves and allow larger waves to pass onto the bar and break in shallower water than usual. On the ebb, currents increase the shoaling effects on the waves and cause them to break on the distal portions of the bar or, if on the upper bar, in deeper water (relative to wave height) than normal. Thus, suspended sediment concentrations in the water column over the bar are higher on flood than during ebb (flood = 5.36 g/ℓ; ebb = 3.08 g/ℓ).

Landward transport across the bar at Murrells Inlet was computed to be 1,500,000 to 1,800,000 m^3/yr. This is much higher than net longshore transport rates (128,000 m^3/yr; Kana, 1976) or gross longshore transport rates (350,000 m^3/yr; Finley, 1976) calculated for nearby beaches. This indicates a partly closed inlet-sediment circulation system which is independent of wave-induced transport on adjacent beaches.

Transport rates calculated for the channel section using the equation of Maddock (1969), which relates load to the cube of the velocity, are an order of magnitude too high when compared to landward transport rates across the upper bar surfaces. The value of such equations in the marine environment is therefore questioned. (Authors)

084 **HUBBARD, D.K., OERTEL, G., and NUMMEDAL, D.** 1979. The role of waves and tidal currents in the development of tidal inlet sedimentary structures and sand body geometry: Examples from North Carolina, South Carolina, and Georgia: Jour. Sed. Pet., 49(4):1073-1092.

Morphologic variability in tidal inlets along the southeastern coast of the United States has been considered with respect to the distribution of large-scale sand bodies, intertidal and subtidal bed forms, and internal sedimentary structures. Data indicate that the morphologic variability in these inlets can be largely explained as a response to waves and tides. Other factors (tidal prism, inlet cross-sectional area and shape, the nature of the back-barrier bay, the degree of flood or ebb dominance, freshwater input, relative changes in sea level and sediment supply) exhibit lesser controls and their effects are less easily quantified.

Three types of inlets are identified: tide-dominated, wave-dominated, and transitional. (1) Tide-dominated inlets are characterized by a deep, ebb-dominant main channel flanked by long, linear channel-margin bars. Flood-tidal deltas are poorly developed or nonexistent. Sand bodies landward of the inlet throat are confined to tidal point bars further landward in the marsh creek system. (2) Wave-dominated inlets are characterized by large, lobate flood-tidal deltas building into wide, open lagoons. The ebb-tidal delta is small and extends only a short distance from the beach. Tidal channels are generally shallow (less then 6 m) and often bifurcate landward and seaward of the throat. (3) In transitional inlets, major sand bodies are typically concentrated in the inlet throat. These inlets vary widely in morphology and sand body geometry.

Logically, this variability should be expressed in the rock record. In a vertical section through a tide-dominated inlet channel, a coarse base, overlain by bidirectional trough cross stratification from the deep channel and ebb-oriented, planar and trough cross stratification from the shallower channel, should be expected. Swash-generated, horizontal plane laminations or slightly inclined accretion beds formed along the channel margins are less likely to be preserved. In contrast, a wave-dominated inlet sequence would contain primarily landward oriented, planar and cross stratification from the shallower channel bottom, overlain by dominantly horizontal or slightly inclined plane laminations from the shallow channel sides. Transitional inlets would produce a variety of sequences, the exact nature of which would reflect the relative importance of waves and tides. (Authors)

085 **HUMPHRIES, S.M.** 1977. Morphologic equilibrium of a natural tidal inlet: Coastal Sediments '77, 5th Sym. of the Waterway, Port, Coas. and Ocean Div., Proc. Amer. Soc. Civ. Engr., 734-753.

A tidal inlet maintains a dynamic equilibrium between the scour of tidal currents and the deposition of sand delivered by the longshore transport. Through periodic monitoring of channel cross-sectional areas and nearby beach profiles at North Inlet, South Carolina, the nature of this equilibrium was investigated from June 1975 to May 1976. The results demonstrate contemporaneous reduction in channel cross-sectional areas and beach erosion, or, increase in channel cross-sectional area and beach accretion.

Two cycles of erosion and deposition occurred between January and May 1976. Beach erosion and inlet infilling appear to occur at a faster rate than the reconstruction of the beach and scour of the inlet which takes many weeks. The mechanism of inlet fill and subsequent erosion is important for determining the pathway of sediment bypassing of an inlet, in that the tidal scour will bring most of the sand from the inlet bottom onto the downdrift swash platform.

North Inlet has a history of southward migration and has been stable at its present location for the past 12 years. Between July 1974 and May 1976, the gross transport rate at a profile location 2 km north of the inlet averaged 830,000 m^3/yr with a net annual transport to the south of 240,000 m^3.

From nine profile locations on the beaches adjacent to North Inlet, data also show dominant longshore transport to the south. An estimated updrift beach erosion of 81,000 m^3/km and downdrift beach accretion of 15,400 m^3/km occurred between June 1975 and May 1976. The morphologic change of the Debidue Island recurved spit confirms the updrift erosion. During the same time period, landward swash bar migration and bar welding onto the beach of North Island are the morphological expressions of downdrift accretion. (Author)

086 **HUNT, S.D.** 1980. Port Canaveral Entrance. Glossary of Inlets, Rpt. No. 9: Univ. of Florida Sea Grant Report No. 39, 50 pp.

The Port Canaveral Entrance report is the ninth in a "Glossary of Inlet" series prepared by the University of Florida Sea Grant Program. Details are given on the geologic setting of the inlet, climate and storm history, morphological changes, hydraulics, and sedimentary process. (Fields)

087 **HUNTLEY, D.A., and NUMMEDAL, D.** 1978. Velocity and stress measurements in a tidal inlet: Conf. Coas. Engr., 16th, Proc., 1320-1335.

Fast-response electromagnetic flowmeters were used in a marginal flood channel of an ebb-tidal delta to assess the importance of wave contributions to the flood dominance of these channels. Measurements were made at a single point in the channel in both ebb and flood currents. The oscillatory motion of waves was a very significant feature of the velocity records, and its magnitude was comparable with the mean flow at all stages of the tide. This observation shows that flowmeters capable of responding accurately to wave velocities are needed to obtain accurate values of mean flow. Some earlier measurements made with slow response flowmeters are probably unreliable. Wave contributions to the mean flow were assessed by looking at the correlation between the low frequency (>17.5 s) oscillations of the along-channel current and the low frequency envelope of the wave velocities. Surprisingly little correlation was found for any time lag, suggesting that wave effects were not important in the mean tidal currents in the channel studied. However, close to low tide on the ebb, conditions existed which appear to have been favorable for the "wave pump" mechanism suggested by Bruun and Viggisson (1973). Significant correlation between the wave envelope and low frequency fluctuations was observed at this time. It is therefore suggested that wave effects can be important to the mean flow in marginal channels with rapidly converging and shoaling mouths which are oriented toward the dominant incident wave direction. (Authors)

088 **HUVAL, C.J., and WINTERGERST, G.L.** 1977. Comparison of numerical and physical hydraulic models, Masonboro Inlet, North Carolina: Simplified Numerical (lumped parameter) Simulation: GITI Rpt. 6, Appendix 4, US Army Corps of Engineers, Coas. Engr. Res. Cen., Fort Belvoir, Virginia, 117 pp.

This report summarizes a mathematical model study of water motions in two horizontal dimensions for Masonboro Inlet, North Carolina. The study was part of the Corps of Engineers General Investigation of Tidal Inlets research program (GITI) and was designed to meet two primary objectives. The first objective was to evaluate the effectiveness of state-of-the-art physical and mathematical modeling techniques in predicting the effects of major changes to an inlet on the hydraulics of the inlet. A second objective was to determine whether simple model tests, performed quickly and for a reasonable cost, could be relied on to evaluate the design of inlet improvements. Masonboro Inlet was in a natural state until August 1965, when major man-made changes to the inlet were initiated. By July 1966, construction of a weir jetty and dredging of a deposition basin and navigation channel had been completed. The mathematical and physical models were initially calibrated using bathymetric and hydraulic data collected at the inlet in September 1969. Selected parts of the calibrated model were subsequently remolded for prediction of hydraulic characteristics for the following conditions: (a) preproject undeveloped inlet conditions November 1964 bathymetry; and (b) modified inlet and north jetty conditions, July 1966 bathymetry. Results of the mathematical model investigations are discussed in this report. (Author)

J

089 **JAIN, S.C., and KENNEDY, J.F.** 1979. An evaluation of movable-bed tidal inlet models: GITI Rpt. 17, US Army Corps of Engineers, Coas. Engr. Res. Cen., Fort Belvoir, Virginia, 82 pp.

The objective of this study was to evaluate the effectiveness of movable-bed tidal inlet hydraulic models in predicting prototype behavior, by comparing model predictions with the observations made in the prototype, and to examine the scaling requirements for such models. Model studies of this type have been conducted in the United States and Canada only by the US Army Engineer Waterways Experiment Station (WES). Seven model studies were conducted by WES during the period 1939 to 1969.

The calibrations of five of these models, as measured by bed topography changes, are evaluated by means of quantitative indicators, including correlation coefficients and root-mean-square (rms) error. The values of correlation coefficients, disregarding measurement errors in model and prototype soundings, were generally low and those of rms error high. If combined model and prototype sounding errors of 2 to 3 ft (0.61 to 0.91 m) were allowed, the correlation coefficients were somewhat higher and the rms errors lower. Evaluation of data from the Galveston Harbor entrance model revealed that the shoaling rates and distribution along the navigation channel predicted by the model are not in good agreement with the prototype data.

It was concluded that the model reproduction of details of bed topography was less accurate than that which might have been obtained had the similitude criteria proposed here been used, and had more complete prototype data been available for calibration. Disagreement between model and prototype is believed to have been due to: (a) scale effects introduced by nonsimilarity of the physical processes; (b) insufficient prototype data for calibration and verification; (c) oversimplification of the available prototype data for use in the model study; and (d) experimental errors. In all cases, the prototype data utilized for model calibration were decidedly inadequate, and the similitude requirements followed, especially those related to the sediment, were deficient in light of recent advances in understanding of coastal sediment transport.

A literature review was conducted to determine the present understanding of and practice concerning similitude requirements for movable-bed coastal inlet models. Similitude conditions for models of this type are recommended.

Also, an appendix has been prepared by the WES to provide comments on the University of Iowa's findings as well as to provide additional information on the background and value of particular model studies. (Authors)

090 **JARRETT, J.T.** 1976. Tidal prism-inlet area relationships: GITI Rpt. 3, US Army Corps of Engineers, Coas. Engr. Res. Cen., Fort Belvoir, Virginia, 32 pp.

The tidal prism-inlet area relationships for inlets on sandy coast established by M. P. O'Brien were reanalyzed using his data and data published by other investigators. In addition, tidal prism and inlet cross-sectional area data developed in the Inlet Classification Study, a subfeature of the Corps of Engineers General Investigation of Tidal Inlets, were also used.

These data result in a total of 162 data points for 108 inlets--59 of which are located on the Atlantic coast, 24 on the Gulf coast, and 25 on the Pacific coast of the United States. The data are grouped into three main categories, namely: (1) all inlets, (2) unjettied and single-jettied inlets, and (3) inlets with two jetties. Within each of these three categories, the data are further subdivided into: (a) inlets on all three coasts, (b) inlets on the Atlantic coast, (c) inlets on the Gulf coast, and (d) inlets on the Pacific coast. Regression analysis was performed on each set of data to determine the equations of best fit and to establish 95 percent confidence limits for the equations and the constants in the equations. The results of the regression analysis, which in all cases yielded an equation of the form $A = CP^n$, in which C and n are constants determined by the regression analysis, indicate that the tidal prism-inlet area relationship is not a unique function for all inlets but varies depending on inlet location and whether or not the inlet has been stabilized with a dual jetty system. (Author)

091 **JARRETT, J.T.** 1978. Coastal process at Oregon Inlet, North Carolina: Conf. Coas. Engr., 16th, Proc., 1257-1275.

This paper describes a method used to determine the existing rate and directional distribution of longshore sediment transport in the vicinity of Oregon Inlet, North Carolina. The method consists of a sediment budget analysis which involves (1) an estimate of volumetric changes from the inlet and adjacent beaches, (2) a wave refraction analysis to determine the variation of longshore energy flux north and south of the inlet, and (3) an estimate of the transport quantities by correlating (1) and (2). A similar approach was taken to estimate longshore sediment transport after construction of a proposed jetty system. A brief discussion of the proposed bypassing system for the stabilized inlet is included. (Fields)

092 **JONES, C.P., and MEHTA, A.J.** 1978. Ponce de Leon Inlet. Glossary of Inlets, Report No. 6: Univ. of Florida Sea Grant Report No. 23, 64 pp.

The Ponce de Leon Inlet report is the sixth in a "Glossary of Inlets" series prepared under the University of Florida Sea Grant Program. Included are the geologic setting, climate and storm history, morphological changes, hydraulics, and sedimentary process of the inlet. (Fields)

0093 **JONES, C.P. and MEHTA, A.J.** 1980. Inlet sand bypassing systems in Florida: Shore and Beach, 48(1):25-34.

The stabilization of a tidal inlet can interfere with the natural bypassing of sedimentary material at the inlet and result in increased shoaling of the navigation channel as well as accelerated erosion of beaches adjacent to the inlet. Several sand bypassing systems have been utilized for the purpose of alleviating these problems, although they have met with varied degrees of success. Some of the bypassing methods employed at tidal inlets in Florida are described, emphasizing their history, economics, and effectiveness. The State's role in sand bypassing has been summarized. Nine inlets, seven on the Atlantic coast and two on the Gulf of Mexico have been included in this study. These are the Florida inlets where means of sand transfer are employed on a continuous or periodic basis. (NTIS Abs.)

K

094 **KACZOROWSKI, R.T.** 1972. Offset tidal inlets, Long Island, New York: M.S. Thesis, Univ. of Mass., Dept. of Geol., 151 pp.

Four of six tidal inlets on the south shore of Long Island, New York, were studied from 1969 to 1971. These inlets are considered unique in that they are of the updrift variety (i.e., the updrift side of the inlet is offset seaward of the downdrift side). The most common type of inlet on the eastern coast of the United States is the downdrift offset variety (i.e., the downdrift side is offset seaward of the updrift side), which occurs along the coasts of the Gulf of Mexico, the Mid-Atlantic states, and New England.

Historic analysis shows that the origin of the Long Island inlets is due to storms that have caused breaches in a barrier island chain. Winds, commonly from later storms, tend to orient the inlets in a north-northeast by south-southwest direction. Detailed tidal-current analysis shows that this natural north-northeast by south-southwest orientation is maintained by tidal currents in the inlets. Each inlet is located west of center of its adjacent bay. The ebb-tidal currents in the eastern channels of the inlets tend to be of longer duration and of higher velocity than those in the western channels. Presumably this is due to a large volume of water contained in the portions of the bays east of the inlets. These currents also affect the westerly littoral drift, causing increased deposition of sand on the updrift side of the inlet, which results in a seaward migration of the updrift side. The ultimate result is that all of the inlets on the south shore of Long Island are oriented in a north-northeast by south-southwest direction with the updrift side of the inlets offset seaward of the downdrift side. (Author)

095 **KADIB, A.A.** 1976. Sedimentation problems at offshore dredged channels: Conf. Coas. Engr., 15th, Proc., 1756-1774.

The paper discusses both bed-load and suspended-load sediment behavior at offshore dredged channels. A method based on theoretical studies of the mechanics of sediment transport under wave and current action is presented to estimate annual maintenance dredging at offshore dredged channels. The rate of sediment deposition per channel units width, Q_d, is determined by the equation:

$$Q_d = Q_{s1} - Q_{s2} + Q_b$$

where

Q_{s1} = rate of suspended load reaching the channel, unit width

Q_{s2} = rate of suspended load across the channel, unit width

Q_b = rate of bed load reaching the channel, unit width

The effects of using a submerged breakwater for relieving sedimentation in the dredged channel, and a design for protection against accretion are also discussed. (Fields)

096 **KANA, T.W.** 1976. Sediment transport rates and littoral processes near Price Inlet, S. C., Hayes, M.O., and Kana, T.W. eds., Terrigenous Clastic Depositional Environments: Coas. Res. Div., Dept. of Geol., Univ. of South Carolina, Tech. Rpt. II-CRD, II-158-171.

A knowledge of littoral processes is necessary for complete understanding of the depositional framework of barrier island coastlines. Several relatively simple techniques have been used at four stations near Price Inlet, South Carolina, to determine littoral transport rates, identify sediment sources and sinks, and measure erosion rates.

The breaches at the four stations can be differentiated as follows:

One updrift station (BU2) is a zone of sediment bypassing and presently maintains a relatively stable shoreline; whereas, the other updrift station (PII) is eroding at ~10 m/yr , providing additional sediment to littoral transport. Of the two downdrift stations, one is accreting (P19) due to its proximity to the enlarging inlet swash bar complex, whereas the other (CA1) is eroding at ~3 m/yr .

An additional sediment source for the area is the beach ridges at the northern end of Bulls Island (6 km north of Price Inlet). A major sink is the ebb-tidal delta of the inlet.

Longshore transport rates at each station have been estimated two ways, from the longshore component of wave energy flux, P_{1s} , and by direct measurement of the suspended sediment concentration in the surf zone. Despite many assumptions used in the calculations, there is a fairly good correspondence of results using the two methods. Transport rates based on wave energy flux and the suspended sediment concentration in the surf zone vary by less than 20 percent at stations BU2 and P19, while the differences at stations P11 and CA1 are 36 percent and 83 percent, respectively. With the exception of station CA1, all estimates of net longshore transport rates are between ~90,000 and 130,000 metric tons/yr to the south. These values are lower, but of the same order, as other rates given for the eastern United States. The results suggest that longshore transport rates predicted from P_{1s} are valid along stable shorelines (station BU2), but less accurate along changing shorelines (stations P11, P19, and CA1). (Author)

097 **KANA, T.W.** 1977. Suspended sediment transport at Price Inlet, South Carolina: Coas. and Ocean Div., Proc. Amer. Soc. Civ. Engr., 366-382.

Daily longshore transport rates were estimated two ways near Price Inlet, South Carolina, between August and November 1975. A transport rate, Q_e , was calculated from the longshore component of wave enrgy flux and compared with a suspended sediment transport rate, Q_s , determined from suspended sediment concentration and longshore current velocity. Over 650 "instantaneous" water samples were collected in the surf zone to establish the typical distribution of sediment in suspension from 4 cm above the bed to the surface. Concentrations range to as much as 50 kg/m^3 at 10 cm above the bed, but the mean for all sample elevations is less than 1 kg/m^3.

Despite several simplifying assumptions, the results show a fair correspondence between Q_e and Q_s . A regression line, $\log Q_e = 0.95 \log Q_s$, incorporates almost half the data points within the 95 percent confidence limits and accounts for 95 percent of the variation. This relatively close correspondence betwen Q_e and Q_s indicates that suspended load accounts for the major portion of sand transport alongshore in the littoral zone. (Author)

098 **KANA, T.W., and HAYES, M.O.** 1980. Hydraulics of tidal delta sedimentation and surf zone sediment suspension: Army Research Office, Research Triangle Park, North Carolina, Rpt. No. ARO-1323F - 6GS, 36 pp.

Since 1975, the US Army Research Office has sponsored research on tidal inlets and surf zone suspended sediment through grants DAAG-29-76-G-0111 and DAAG-29-79-G-0011 (Miles O. Hayes, principal investigator) to the University of South Carolina. The latter grant terminated on 30 June 1980. Research projects wholly or partially supported by ARO under these awards have produced two Ph. D. dissertations, two M.S. theses (plus two due for completion in December 1980), one sampling equipment design, and, to date, 21 publications or technical reports. Fieldwork for the bulk of the studies was performed at Price Inlet, South Carolina, and along adjacent barrier islands. Laboratory analysis and report preparation were completed at the University of South Carolina's Coastal Research Division. This final report contains abstracts summarizing results of the investigations, and lists of publications produced under these grants and University of South Carolina personnel receiving partial support from the Army Research Office. (Authors)

099 **KANA, T.W., WILLIAMS, M.L., and OLSEN, E.J.** 1984. The relocation of Captain Sam's Inlet, Conf. Coas. Engr., 19th, Proc., 490-491.

Between February and March 1983, Captain Sam's inlet was relocated approximately 2.5 km north of its recent position. The modifications were intended to control erosion along the downdrift barrier island. Approximately three weeks after completion of the project, a new ebb-tidal delta began to form at the mouth of the relocated inlet. In addition, sediment from the abandoned tidal delta was shifted onshore to critically eroded beaches on the downdrift barrier. The relocation of Captain Sam's inlet represents a major departure from the conventional shore-protection or beach-restoration projects. (Fields)

100 **KEULEGAN, G.H., and HALL, J.V.** 1950. A formula for the calculation of the tidal discharge through an inlet: US Beach Erosion Board Bull. 4(1):15-29.

During the course of an investigation of Santa Rosa Island, Florida, a number of engineering problems arose which required special study because of the lack of field data. The most interesting of these problems inlvolved the advisability of cutting an inlet through the island. The specific problem, which required special mathematical treatment, was brought about through the determination of the division of flow between Pensacola Inlet and the relatively small cut through Santa Rosa Island. Inasmuch as adequate field data were available in the vicinity of the proposed cut, this locality presented no problem. However, the only information available for Pensacola Inlet was the tidal prism of Pensacola Bay. With this tidal prism quantity in mind as the only available working data, certain basic assumptions were made and a formula was derived for the determination of the maximum discharge that could be expected through the inlet at any tidal cycle. Since the formula as derived checked remarkably well when applied to a number of inlets that had been gaged, it was thought that the information would be of value to engineers. Hence it is presented in this monography as a matter of record. In the following pages there is a complete mathematical analysis of the problem including the basic assumptions, the development of the formula, the test cases as applied to four inlets on the Atlantic coast, the development of a correction factor introduced to adjust the basic assumptions, and a demonstration of the practical application of the formula. (Authors)

101 **KIESLICH, J.M.** 1977. Case history of Port Mansfield Channel, Texas: GITI Rpt. 12, US Army Corps of Engineers, Coas. Engr. Res. Cen., Fort Belvoir, Virginia, 66 pp.

This report presents a case history and analysis of Port Mansfield Channel, an artificial, jettied inlet between the Gulf of Mexico and Laguna Madre, Texas. Deposition has occurred in the channel entrance since its opening. Seaward migration of the updrift beach and shoaling in the channel entrance indicate that sand is bypassing the jettied entrance. Short-term predictions of inlet stability using the O'Brien prism-area relationship (Jarrett 1976), Escoffier's (1940) stability criteria, and the Bruun and Gerritsen (1960) ratio of tidal prism to the gross annual longshore transport rate correctly predict the unstable nature of the channel. Tidal exchange volumes and velocities are not large enough to maintain the design cross-sectional area in the presence of the existing longshore transport. (Author)

102 **KIESLICH, J.M.** 1981. Tidal inlet response to jetty construction: GITI Rpt. 19, US Army Engineer Waterways Experiment Station, Vicksburg, Mississippi, 66 pp.

Thirteen tidal inlets located on the Atlantic, Gulf, and Pacific coasts of the continental United States are selected for a study of the response of inlet ocean entrances to man-made improvements. Inlet entrance behavior following jetty construction was evaluated and guidelines for the functional design of inlet entrance improvements are suggested. The inlets considered in the study were those where a single updrift or downdrift jetty was built first.

The construction of single jetties at inlet entrances has resulted in migration of the channel thalweg toward the jetty regardless of the inlet-bay orientation, the jetty angle with the shoreline, the position of the jetty relative to the direction of net longshore sediment transport, the ratio of net-to-gross transport, or the gross transport. In some cases, this has caused undermining of the jetty.

For the inlets studied, the annual channel thalweg migration averaged 31 percent of the total distance available for migration following construction of a single updrift jetty, and 49 percent of the total distance available for migration following construction of a single downdrift jetty.

Accretion at the updrift shoreline and erosion at the downdrift shoreline usually followed construction of a single updrift jetty. Accretion rates at the updrift shoreline ranged up to about 800 ft (244 m) per year. Data on erosion rates of the downdrift shoreline following construction of an updrift jetty are available for only a limited number of inlets. Sufficient information was not available to generalize the response of either adjacent shoreline following construction of a single downdrift jetty.

The channel cross-sectional area usually decreased following construction of a single updrift jetty; the decrease in area ranging up to 40 percent. Sufficient data were not available to quantify channel area response following construction of a single downdrift jetty. (Author)

103 **KING, D.B., and SHEMDIN, O.H.** 1974. Dynamics of inlets and bays: Tech. Rpt. 22, Coas. and Oceano. Engr., Lab., Univ. of Florida, Gainesville, Florida, 86 pp.

The equations for tidal flow through inlets into bays have been studied by many investigators. Perhaps the best known is the one by Keulegan in 1951. He considered nonlinear friction but assumed no iniertia in the inlet, no river discharge, constant inlet cross-section and bay surface area over a tidal cycle, and uniform bay elevation.

This study analyzes these assumptions in four models: an inertia model, a river discharge model, a changing area model, and a shallow-water wave model, and predicts their effects. The results are presented in graphical and equation form. They are then compared to real inlets and the limitations of each model are discussed. (Authors)

104 **KOMAR, P.D.** 1973. Computer models of delta growth due to sediment input from rivers and longshore transport: Geol. Soc. Amer. Bull., 84:2217-2226.

Computer-simulation models are developed to investigate the growth and equilibrium shape of a river delta in which wave action is the dominant force in redistributing sands deposited at the river mouth. Common values of sediment supply by rivers are used, and known relations for sand transport along beaches are applied. Although of a preliminary nature, the models appear to yield reasonable comparisons with real beaches and delta shapes. The models indicate that the deltas quickly reach an equilibrium configuration in which the wave energy flux is just capable of transporting and redistributing along the shore all the sand supplied by the river. The wave breaker angle decreases systematically along the delta away from the river mouth due to a progressive decrease in the quantity of river sand remaining to be transported (with increasing distance from the river mouth an increasing proportion of the river sand has already been deposited). When the wave energy flux is low or the river sediment supply too high for the existing waves, nearly all the sand remains near the river mouth, producing one distributary which, if duplicated, would form a bird-foot delta. Oblique wave approaches produced asymmetric deltas but the asymmetry was not as pronounced as anticipated. The application of such simulation models to real case studies of shoreline alteration, natural or man-made, is also discussed. (Author)

105 **KOMAR, P.D., and TERICH, T.A.** 1976. Changes due to jetties at Tillamook Bay, Oregon: Conf. Coas. Engr., 15th, Proc., 1791-1811.

Bayocean Spit, separating Tillamook Bay from the Pacific Ocean on the north Oregon coast, underwent severe erosion following construction of a north jetty at the bay entrance in 1914-17. This erosion ultimately led to the complete breaching of the spit in 1952. Simultaneous to the spit erosion south of the entrance, the shoreline north of the north jetty advanced seaward by some 600 m (2,000 ft). This pattern of erosion and deposition following jetty construction has generally been interpreted as the jetty blocking a large north to south net littoral drift in the area, estimated by a previous study at 620,000 m^3/yr (800,000 yd^3/yr). Our reexamination of the shoreline changes and patterns of erosion and deposition following jetty construction disagrees with this interpretation, and instead we conclude that all the changes resulted from local rearrangements of the beach due to the disrupted equilibrium following jetty construction, but at the same time maintaining an overall condition of zero net littoral drift. This interpretation is supported by other evidence that indicates a near-zero net drift on this portion of the Oregon coast. Thus severe coastal erosion can result from jetty construction even in areas of zero net littoral drift.

A new south jetty has been recently completed (1974). The result has been further realignments of the shoreline with accretion and shoreline advance immediately south of the south jetty. This provides further confirmation that a zero net littoral drift exists in the area.

This study also demonstrates the effects of building only a single jetty rather than a pair of jetties. Following construction of the north jetty, the outer bar or ebb-tidal delta at the Tillamook Bay inlet grew appreciably in size. Sand deposited there came from erosion of Bayocean Spit further to the south. The shoal growth pushed the main channel at the entrance against the north jetty where it has remained since jetty completion. In the process, the channel became much deeper and narrower than the channel geometry prior to jetty construction. (Authors)

106 **KONDO, H.** 1978. Design procedure of artificial channels for tidal entrances: Coas. Engr. in Japan, 21:191-199.

A generalized design procedure is proposed for artificial entrance channels for tidal inlets on sedimentary coasts. The artificial channels are classified into four kinds, according to the proposals to utilize them, each of which are demanded to furnish different requirements.

Configuration of bottom topography of tidal entrances is examined to find three major characteristics. Probable cause of the deep appearing shoreward end of entrance is discussed. Application of the one-dimensional analytical method is introduced which can effectively predict tidal currents and bay tide. Existence of the depth of maximum channel velocity, which is one of the most important parameter for the channel design, is explained for an existing entrance.

The criterion proposed recently by the writer for stable tidal entrances is discussed taking into account the littoral drift. It is found that an entrance affected by less littoral drift and by smaller sea tidal range has relatively greater flow areas in equilibrium state. Sediment transport rate by the channel currents is approximated by applying the known formulae for steady flow. (Author)

L

107 **LEAN, G.H.** 1980. Estimation for maintenance dredging for navigation channels: Hydraulics Research Station, Wallingford, Oxon, Crown Copyright, 73 pp.

This report deals with methods of predicting maintenance dredging in those parts of navigation channels that are situated in the outer areas of estuaries and offshore. It discusses the behavior of channels dredged across flow lines, and examines the influence of various factors on channel shape.

It deals in turn with methods of predicting infill due to the action of currents, gravity and wave activity, and the special problems that arise when the bed is composed of a cohesive material such as mud or silt. It discusses the application of tracers to estimate infill, and also trial dredging.

The report was prepared in reponse to a demand for a critical assessment of existing methods of predicting maintenance dredging in access channels, and is based on a review of available literature backed by experience gained in investigating practical problems at the Hydraulics Research Station. (Author)

108 **LIN, P.M.** 1969. Modeling of sediment transport in the vicinity of inlet and coastal region: M.S. Thesis, Univ. of Florida, Gainesville, Florida, 91 pp.

Sediment transport in the vicinity of inlets and coastal regions depends on the combined bottom shear stresses due to both currents and waves. The modeling of the movement of the bed load is controlled by the Froude law, bottom shear stress, wave steepness, and friction factor. Assuming Einstein's theory of bed-load function can be applied to this study, an analysis was performed after conducting experiments in the flume and model basin. The results of bed-load transport along the beach were in reasonable agreement with the estimated theoretical values. However, the sedimentological time scales for the three bed materials, sand, walnut shell, and coal, were not in satisfactory agreement. (Author)

109 **LUCK, G.** 1976. Inlet changes of the East Frisian Islands. Conf. Coas. Engr., 15th, Proc., 1938-1957.

The seven sandy islands of the East Frisian group would appear to be initially formed and now continually supplied with sand from the West Frisian group and the mainland to the west. The inlets between these islands are in dynamic equilibrium with the strong tidal currents of the near 2.5-m range in the area. Hydrographic information dating back to 1650 permits the development of a hypothetical model which explairs the historic changes and might predict future trends. The installation of coastal defense structures on the eroding western extremities of some islands in the mid 19th century has greatly influenced the bars by which sand is transported from island to island in an easterly direction. (Author)

110 **LYNCH-BLOSSE, M.A., and DAVIS, R.A.** 1977. Stability of Dunedin and Hurricane Passes, Florida: Coastal Sediments '77, 5th Sym. of the Waterway, Port, Coas. and Ocean Div., Proc. Amer. Soc. Engr., 774-789.

Dunedin and Hurricane Passes are adjacent tidal inlets on the coast of northern Pinellas County, Florida. Formation of Dunedin Pass predates available historical data whereas Hurricane Pass was created by a tropical storm in 1921. During the past century, Dunedin Pass has been characterized by narrowing, shoaling, and northward migration. Since its formation, Hurricane Pass has increased its cross section and tidal prism while remaining in essentially the same position.

Construction of the Clearwater Causeway (1925-26) and Honeymoon Island Causeway (1960-63) has significantly altered the tidal prisms and circulation in the inlets of northern Pinellas County and in St Joseph's Sound. The apparently marked decrease in tidal prism associated with these man-made alterations has provided indications that this area can no longer maintain two inlet systems as evidenced by the present (1976) near-closure of Dunedin Pass.

Since formation of Hurricane Pass and the subsequent causeway construction, there has been a gulfward progradation of the southern portion of Caladesi Island while the north end has been eroding. The result has been a significant rotation of the island. This has been accompanied by nearly a kilometer of northward migration of Dunedin Pass since 1883. (Authors)

M

111 **MACHELMEHL, J.L.** 1977. Design, construction and response of a new barrier island tidal inlet, 2nd Int. Sym. Dredging Technology: Texas A&M Univ., C2-15, 2-26.

On December 23, 1971, New Drum Inlet was opened between Core Sound and the Atlantic Ocean by dredging and explosive excavation. The dredged material was used to create 30 acres of marsh. The inlet widened to 900 m by 1973. The material scoured by tidal currents was deposited on interior shoals. The rapid formation of interior shoals precluded the sustained use of the inlet. Tidal flow and wave transmission through the inlet were found to be greater at New Drum Inlet than for a well-established barrier island tidal inlet. The inlet is still in a transition stage. (Author)

112 **MACHELMEHL, J.L., CHAMBERS, M., and BIRD, N.** 1977. Flow dynamics and sediment movement in Lockwoods Folly Inlet, North Carolina: Univ. of North Carolina Sea Grant College, Published No. UNC-5G-77-11, 139.

A numerical simulation model for the computation of tidal and freshwater flow exchange through a coastal inlet (developed by Amein (2) was modified and calibrated with field data (current, water surface elevation, and bottom topography) for Lockwoods Folly Inlet, N. C. The model was then used to predict the flow patterns in the inlet.

A generalized hypothesis of the patterns of sediment movement through and bypassing the inlet was formulated from an evaluation of the flow data and from an analysis of the orientation and structure of the bed forms observed in the inlet and on the offshore bar. The bed forms were analyzed in the field and from an uncontrolled mosaic made from multispectral aerial photographs. Confirmation and refinement of the transport rates and movement patterns during ebb tide were made by introducing 454 kg (1,000 lb) of fluorescent tracer sands in two colors into the inlet channels. The sediment movement through the inlet was established and correlated with the numerical simulation model. Confirmation and refinement of the transport rates and movement patterns during flood tide were made by introducing 680 kg (1,500 lb) of fluorescent tracer sand in three colors into the surf zone on the updrift beach and on the offshore bar. The sediment movement indicated the existence of bar bypassing which was the dominant bypassing mechanism and tidal flow bypassing. The bypassing mechanism of the inlet was found to agree with other Atlantic Coast inlets.

When used in conjunction with an analysis of bed form and tracer sand data the numerical simulation model was found to be a valid method of monitoring the high energy inlet environment. (Authors)

113 **MACHELMEHL, J.L., and FORMAN, W.** 1980. Flood-tidal delta in a new barrier island tidal inlet: Bull. Assoc. of Engr. Geol., XVII(4):163-191.

A new tidal inlet was opened between Core Sound and the Atlantic Ocean in North Carolina by the US Army Corps of Engineers in December 1971. A study was initiated at the new inlet: (1) to evaluate the response of the flood-tidal delta (flood shoal) to ocean currents, (2) to investigate the growth pattern of the flood-tidal delta, and (3) to develop a sediment budget for the inlet system. Aerial photographs were used to study the large-scale spatial and temporal changes in the delta. Field studies (current, sediment characteristics, and tracer) were designed to evaluate the pattern of sediment movement on the delta.

The study indicated that, between December 1971 and June 1975, there was a constant rate of areal, longitudinal, and lateral growth of the flood-tidal delta. After June 1975, however, the rate of landward growth decreased while the rate of lateral and areal growth continued through March 1977. The sediment budget for the inlet indicated approximately 13 percent of the littoral drift was retained within the inlet system, thus indicating the growth of the flood-tidal delta will probably continue at a rate of 275,250 to 321,115 m^3/yr (calculated). (Authors)

114 **MASH, F.D., BRANDES, R.J., and REAGAN, J.D.** 1977. Comparison of numerical and physical hydraulic models, Masonboro Inlet, North Carolina, Appendix 2, Vol 1, Numerical Simulation of Hydrodynamics (WRE): GITI Rpt. 6, US Army Corps of Engineers, Coas. Engr. Res. Cen., Fort Belvoir, Virginia, 186 pp.

A two-dimensional finite difference tidal hydrodynamics model has been adapted to Masonboro Inlet, North Carolina. The model was initially calibrated to simulate prototype conditions of September and October 1969. Operational runs were then undertaken to simulate tides and currents corresponding to preproject undeveloped inlet conditions of June 1967. For each case, the model was operated with mean and spring ocean tides. The tidal hydrodynamics model applied at Masonboro Inlet uses an explicit numerical solution of the basic equations of motion and the continuity equation. As structured, the model includes bathymetric data for the inlet, bottom roughness, inundated areas, and other features of the system. Because of the size and detail required in the simulations, a dual-model approach is employed. In this technique a coarse grid model is utilized to compute tidal flows which in turn are applied as boundary conditions to a finer submodel of the immediate inlet area. Special requirements necessary for sequential operation of the two models are presented. (Authors)

115 **MASCH, F.D., BRANDES, R.J., and REAGAN, J.D.** 1977. Comparison of numerical and physical hydraulic models, Masonboro Inlet, North Carolina. Appendix 2, Vol 2, Numerical Simulatiom of Hydrodynamics (WRE): GITI Rpt. 6, US Army Engineer Coas. Engr. Res. Cen., Fort Belvoir, Virginia, 189 pp.

HYDTID is constructed and formulated in such a manner that the sequential flow of program control necessary for solution using high speed digital computers can be easily understood. The basic computer language used is Fortran V and the model has been successfully applied using the CDC 6600 and 6400, the UNIVAC 1108 and 1106, and the RCA Spectra 70/45 computers. In its present form HYDTID is essentially machine independent. The computation time and storage depend on the size of the system being modeled, the mesh size and time-step of the system being used, the number of computational or water cells in the grid network, and the length of simulation time desired. For the Masonboro Inlet problem, the coarse grid model required about four minutes of UNIVAC 1108 time to simulate one 12.5-hr tidal cycle and to generate the input flows for the fine grid submodel. The fine grid submodel required about 40 min of computer time to simulate one cycle. (Authors)

116 **MAYOR-MORA, R.E.** 1977. Laboratory investigation of tidal inlets on sandy coasts: GITI Rpt. 11, US Army Engineer Coas. Engr. Res. Cen., Fort Belvoir, Virginia, 106 pp.

Experiments were conducted on a fine sand barrier separating two 1-ft-deep basins representing an ocean and a 94- by 64-ft bay. Pilot channels with varying geometric characteristics were cut through the barrier to communicate the basins and thus create an ocean-inlet-bay system subsequently subjected to ocean tide and wave action. Measurements were made of cross-sectional areas, water-surface elevations at ocean, bay, and inlet, and inlet current velocities for a number of cycles (sinusoidal tides) until the water-surface fluctuations in the bay became periodic for each run. Exploratory studies included runs with jettied inlets, a run with "freshwater" inflow into the bay, inlets under mild and steep ocean waves, and runs to determine the effect of model bed ripple orientation on the friction coefficient of the inlet channel. Experimental data are presented in tabular and photographic form, and as plots correlating the various dimensionless hydraulic parameters (e.g., tidal range damping coefficient, bay superelevation, mean current velocity time lag between maxima and minima, duration of ebbtide) to the repletion coefficient, K, and to a proposed parameter, $K\sqrt{F}$. These results are then compared to the basic theoretical solution of the problem by Keulegan (1967) and to an extension of the Keulegan theory (the lumped parameter approach) developed by Huval and Wintergerst (in preparation 1977). Comparison of tidal prisms and minimum flow areas are made between the laboratory results and available field data. An appendix includes plots summarizing the inlet channel's geometrical properties for the experiments. (Author)

117 **McNAIR, E.C.** 1976. Model materials evaluation, sand tests; Hydraulic Laboratory Investigation: GITI Rpt. 7, US Army Engineer Waterways Experiment Station, Vicksburg, Mississippi, 60 pp.

A laboratory investigation was performed to define responses of a natural quartz sand to various hydraulic conditions. The results demonstrate the performance of the material in a movable-bed model and, when compared with the responses of other materials, may provide a basis for the selection of optimum materials for various movable-bed modeling requirements. Twenty-one tests were performed with a 40-ft-long beach containing an inlet and with unidirectional, steady flows through the inlet substituting for tidal flows. The geometric characteristics of the inlet channel, beach profiles, inlet configurations, and material transport were observed for conditions with and without waves and for various magnitudes of flood and ebb flows. The tests showed that the minimum channel area, the channel width at the location of the minimum area, and the hydraulic radius at the location of the minimum area were strongly related to the rate of flow through the channel. The rate of material transport was found to be weakly related to channel flow rate, but the sparseness of data observations with time precluded definite evaluation of this. The ability to scale channel geometry was demonstrated. The rate of material transport appears to be a scalable quantity, but the scaling relations require additional experimentation for definition. (Author)

118 **McTAMANY, J.E.** 1982. Evaluation of physical and numerical hydraulic models, Masonboro Inlet, North Carolina: GITI Rpt. 22, US Army Engineer Coas. Engr. Res. Cen., Fort Belvoir, Virginia, 51 pp.

A fixed-bed distorted-scale physical model, a two-dimensional vertically integrated numerical model, and a spatially integrated numerical model were calibrated to determine prototype conditions at Masonboro Inlet, North Carolina, in September 1969. Comparison of model results with prototype data showed that the physical model and the two-dimensional numerical model reproduced prototype conditions equally well. A second complete set of prototype data, including revised bathymetry in each model, was subsequently obtained at Masonboro Inlet in July 1974. After the bathymetry was updated, the models were run using the observed ocean tide as a forcing condition. The model predictions were then compared with prototype data without further recalibration. Both the physical and the two-dimensional numerical models reproduced observed tidal records and vertically averaged velocities equally well. No appreciable improvement in tidal height or velocity predictions was obtained by modeling prototype wind waves in the physical model. The waves caused a slight increase in bay water levels that also occurred in the prototype. Neither numerical model had the capability to model wind waves. The spatially integrated model only predicts the average bay water level and the inlet mean velocity time histories. The predictions from the other models and the prototype data were averaged for comparison with the spatially integrated model. The spatially integrated model did not predict the mean inlet velocities significantly better than the other two models. The accuracy of the spatially integrated model in predicting mean inlet velocities appears to be less sensitive to calibration than the more detailed physical and numerical models tested in this study. (Author)

119 **MEHTA, A.J.** 1975. A long-term stability criterion for inlets on a study coast: Coas. and Oceano. Engr. Lab., Univ. of Florida, Gainesville, Florida, Pub. No. 75/0018, 28 pp.

Some tidal inlets have relatively clean stable channels requiring little maintenance dredging, whereas others shoal heavily due to the deposition of littoral sediments, and the channel and the outer bar often exhibit significant migratory tendencies. Such inlets may also eventually become susceptible to storm closure. The long-term stability is a matter of concern in the maintenance of existing inlets as well as in the design of new inlets. Often, it is important to know if a storm breakthrough cut will remain open or close itself under the influence of "normal" wave action and associated littoral drift, subsequent to the storm.

A dimensionless stability coefficient has been defined in order to characterize the stability of an inlet on a sandy coast. The definition is based on the notion that stability is determined by the cumulative action of two opposing agencies, namely the nearshore wave energy which drives sand toward the inlet entrance, and the energy associated with the tidal flow which attempts to scour the accumulated sand. The criterion categorizes inlets as having good, intermediate, or poor long-term stability. Results from a model inlet study allow the application of the proposed criterion to model-sized inlets. (Author)

120 **MEHTA, A.J.** 1978. Bed friction characteristics of three tidal entrances: Coas. Engr. (2):69-83.

The regimes of flow and sediment transport through a tidal entrance are contingent upon, among other factors, the temporal and spatial distributions of the shear stress at the channel bed, defined in terms of the depth-averaged velocity, a friction factor or a Manning's n , and an equuivalent sand bed roughness. Direct measurement of these parameters should, therefore, yield basic information on the flow and sediment transport characteristics of the entrance. Three entrances, located on the Gulf Coast of Florida, were selected for hydraulic measurements. In two of the three entrances, bed friction characteristics were derived from near-bed velocity measurements and at the third entrance the same were obtained from measured water surface slopes in the channel. The near-bed velocity profiles were found to be logarithmic, and the effect of flow inertia was found to be significant only for relatively short time periods close to slack water. In the fully rough range of flow the bed shear stress-velocity relationship was found to follow the square law with a characteristic friction factor and Manning's n for the entrance. The measured maximum friction velocity and the friction factor have been used to estimate the tidal prism--throat cross-sectional area ratio which is then compared with the same obtained from flow discharge measurements. A reasonable agreement is observed, thus attesting to the validity of the measured friction factors. (Author)

121 **MEHTA, A.J., ADAMS, W.D., and JONES, C.P.** 1976. Sebastian Inlet. Glossary of Inlets, Report No. 3: Coas. and Oceano. Engr. Lab., Univ. of Florida, Gainesville, Florida, 52 pp.

The Sebastian Inlet report is the third in a "Glossary of Inlets" series prepared under the University of Florida Sea Grant Program. Sebastian Inlet is a man-made cut connecting the Atlantic Ocean to the Indian River on the east coast of Florida, approximately 45 miles south of Cape Canaveral. Details are given on the geologic setting of the inlet, climate and storm history, jetty improvements, morphological changes, hydraulics, and sedimentary process. (Fields)

122 **MEHTA, A.J., BYRNE, R.J., and DeALTERIS, J.T.** 1976. Measurement of bed friction in tidal inlets: Conf. Coas. Engr., 15th, Proc., 1701-1720.

The flow characteristics and the stability of a tidal inlet are governed, among other factors, by the channel bed friction. In order to determine the bed shear stress regime and the frictional characteristics, near-bed velocity profiles were obtained at the throat sections of two inlets, John's Pass and Blind Pass, on the Gulf Coast of Florida. A specially designed steel cage with five current meters in a vertical array was used to obtain the profiles in the bottom one meter of the flow.

The profiles were found to be logarithmic but it is noted that, especially near the times of slack water, the effect of inertia becomes significant. However, during the major part of the flood or ebb flow period, frictional effects are dominant. In the fully rough regime of flow, the bed-shear stress-velocity relationship is found to follow the square law, with a constant, characteristic friction factor and Manning's n for each inlet. This friction factor is used in hydraulic formulas, based on uniform, steady open channel flow relationships, to obtain the tidal prism-throat cross-sectional area ratio, which is then compared with that obtained from flow discharge measurements. Agreements and discrepanies in the comparison are discussed. The relationship between the bed-shear stress at incipient motion and the grain size at the bed is reviewed, and it is noted that the observed relationship at the two inlets does not agree with the well-known correlation of Shields for uniform sandy beds. (Authors)

123 **MEHTA, A.J., and CHRISTENSEN, B.A.** 1983. Initiation of sand transport over coarse beds in tidal entrances: Coas. Engr. (7):6-75.

A tidal entrance often acts as a source or a sink in the littoral zone. At many entrances in biologically productive regions the bed in the vicinity of the throat section (minimum flow area) is composed of sediment containing coarse material including large shells, with sand occurring in the interstitial regions between the shell-defined roughness elements. A stochastic relationship giving the critical bed-shear stress for the initiation of sand transport under these conditions is applied to hydraulic and sedimentary data obtained from two entrances in Florida. The results agree well with the critical bed-shear stresses derived from data based on the observation of sand movement at the bed. The entrainment function based on observations is found to be approximately three times the value obtained from Shields' criterion. A practical implication is that the use of Shields' criterion in the computation of the rate of sand transport will in general overpredict the rate through the entrance. (Authors)

124 **MEHTA, A.J., and HOU, H.S.** 1974. Hydraulic constants of tidal entrances II: Stability of Long Island Inlets: Tech. Rpt. No. 23, Coas. and Oceano. Engr. Lab., Univ. of Florida, Gainesville, Florida, 103 pp.

The susceptibility of a tidal inlet to closure involves a consideration of two opposing agencies, namely, (a) the onshore wave energy which tends to drive littoral material toward the entrance and (b) the tidal flow which attempts to scour this material to keep the entrance channel open. This concept has been explored with references to the stability of the inlets on the south shore of Long Island. A generalized criterion for stability is proposed and it is found that this criterion can be used to classify inlets ranging in size from a laboratory model to large natural entrances. (Authors)

125 **MEHTA, A.J., and JONES, C.P.** 1977. Matanzas Inlet. Glossary of Inlets, Rpt. No. 5: Univ. of Florida Sea Grant Rpt. No. 21, 86 pp.

The Matanzas Inlet report is the fifth in a "Glossary of Inlets" series prepared under the University of Florida Sea Grant Program. The report compiles historical, geological, climatological, morphological, hydraulic, and sedimentary data bout Matanzas Inlet. (Fields)

126 **MEHTA, A.J., JONES, C.P., and ADAMS, W.D.** 1976. John's Pass and Blind Pass. Glossary of Inlets, Rpt. No. 4: Univ. of Florida Sea Grant Rpt. No. 18, 75 pp.

The John's Pass and Blind Pass report is the fourth in a "Glossary of Inlets" series prepared by the University of Florida Sea Grant Program. The purpose of the series is to provide a summary of the significant available information and known documentation for each inlet. (Fields)

127 **MEHTA, A.J., and ZEH, T.A.** 1979. Investigation of the hydrodynamics of inlet plume: Proc. of the Special Conf. on Conservation and Utility of Water and Energy Resource, San Francisco, California, 478-485.

For the maintenance of a navigation channel and the control of erosion of nearby beaches, the mechanism by which sand is bypassed across an inlet channel is a matter of considerable interest. Commonly employed means of transferring sand such as cutterhead plants or dredges which utilize diesel or electrical power are becoming increasingly expensive, and it appears reasonable to design inlets wherein a major portion of the energy required for sand transfer is provided by the flow itself. Such a design consideration merits an understanding of the hydrodynamics of flow distribution near the inlet. A study of this nature at a small inlet, Sikes Cut, is reported. Sikes Cut provides an access to the Gulf of Mexico from Apalachicola Bay, which is a large and shallow oyster producing body of water in Florida. Two objectives of the investigation were (1) to determine the extent of tidal influence of Sikes Cut in Apalachicola Bay and (2) to use Landsat satellite imagery in order to interpret the ebb flow pattern from the inlet into the Gulf. (Compendex Abs.)

128 **MIKKELSEN, L., MORTENSEN, P., and SORENSEN, T.** 1980. Sedimentation in dredged navigation channels: Conf. Coas. Engr., 17th, Proc., 719-1734.

The paper presents a theoretical model for sedimentation in dredged entrance channels. A test pit at the mouth of the Forcados Entrance in the Western Niger Delta, Nigeria, was used to test the sedimentation model. Sediment transport rates in combined waves and currents were calibrated using test pit deposition rates, and measured wave and current parameters. Using the calibrated transport rates, the theoretical sedimentation model, and the wave and current statistics, it is possible to calculate the expected annual sedimentation in the dredged channel. (Fields)

129 **MOTTA, V.F., and BANDEIRA, J.V.** 1974. Comparison between the results of littoral-drift computations and cubature of deposits in a dredged channel: Conf. Coas. Engr., 14th, Proc., 726-740.

The total annual volume of littoral drift on either side of the mouth of Sergipe estuary, in the Northeast of Brazil, has been determined by applying Caldwell's, Castanho's, and Bijker's methods to the wave characteristics that had been recorded at a 20-m depth of water, over a whole year, for the design of an offshore oil terminal.

The three computation methods yielded the same order of magnitude which was found to amount to 800,000 m^3/year. The dominant drift is southwestward, and its predicted amount is 660,000 m^3/year. It was also found that although the three methods lead to total results of the same order of magnitude, they do not agree as to the variation of littoral drift over the year for the same waves.

An 8-m-deep shipping channel has been dredged across the bar. The channel was surveyed in December 1971, August and December 1972, and a cubature of the deposits was made after the littoral drift computations had been carried out. As the latter had been performed on a monthly basis, a comparison became possible between predicted and actual volumes of deposits for the same lengths of time.

The predicted volumes for the whole year were found to be from 34 percent to 46 percent greater than the actual results. However, for the time interval August-December 1972 a remarkable agreement was found between predicted and actual results. (Authors)

N

130 **NELSON, R.C., and KEATS, A.J.** 1980. A coastal inlet with fixed bed and mobile sides: Conf. Coas. Engr., 17th, Proc., 2534-2549.

Barwon Heads Inlet in Victoria, Australia, has a fixed bed of exposed rock, and side boundaries of unconsoliated sand. The purpose of the case study was to examine the response of the throat section to natural hydraulic and meteorological events. Various equilibrium criteria developed from inlets with unrestricted bed mobility were applied to Barwon Heads Inlet.

Results of the study showed that variations in maximum and minimum cross-sectional areas and width were approximately twofold. Enlargement of the inlet cross-sectional area was primarily caused by freshwater flood flows, however, high meteorological tides combined with severe and prolonged southwesterly sea and swell states also caused an increase in the area. Recovery of the cross-sectional area occurred following floods, during times of moderate seas, swell, and mean sea level. Although the depth of the inlet was fixed by bedrock exposures, the inlet's cross section, maximum tidal velocity, and tidal prism agree with the equilibrium criteria developed from inlets with mobile beds. (Fields)

131 **NIELSEN, A.F., and GORDON, A.D.** 1980. Tidal inlet behavioral analysis: Conf. Coas. Engr., 17th, Proc., 2461-2480.

The paper includes a discussion of some of the limitations of existing stability theories which are commonly used to design and predict the development of tidal inlets. A new method of inlet behavioral analysis based on the concepts of O'Brien and Dean (1972) and Bruun (1977, 1978) is presented. The major features of this approach include an examination and description of ocean bar morphology, current patterns and sediment transport conditions, and head loss variations, flood and ebb tidal current alterations, and cross-sectional area changes caused by modifications of bar morphology. A regime type approach is used to predict hydraulic conditions in the inlet/estuary system, and a predictive sediment budget model based on sediment transport formula and the calculated hydraulic conditions is also developed.

A case study utilizing the inlet behavioral analysis is applied to the Wallis Lake Estuary, on the New South Wales coastline. Existing stability theories do not accurately describe the development of the estuary, whereas application of the dynamic behavioral analysis produces interesting results which are in good agreement with field observations. (Fields)

132 **NIEMEYER, H.D.** 1984. Wave deformation and energy dissipation due to breaking on a tidal inlet bar: Conf. Coas. Engr., 19th, Proc., 136-137.

Results of field measurements collected in the offshore and nearshore region of Nordeermeg, an island in the East Frisian Wadden Sea, are presented. Special emphasis is placed on wave transmission across the offshore bar of a tidal inlet. Results show that a decrease in wave height and period is primarily determined by different boundary conditions. In addition, wave spectra tend to become multipeaked over the bar, with increasing relative energy corresponding to higher frequencies. Refraction of waves around the bar creates a sorting effect such that the wave patterns are nearly always the same in the landward part of the inlet. (Fields)

133 **NUMMEDAL, D., and FISCHER, I.A.** 1978. Process-response models for depositional shorelines: The German and the Georgia Bights: Conf. Coas. Engr., 16th, Proc., 1215-1231.

Sediment dispersal patterns in tidal inlets within the German and the Georgia Bights are found to be controlled by three major environmental factors: (1) the tide range, (2) the nearshore wave energy, and (3) the geometry of the back-barrier bay. Both embayments chosen for study are characterized by high wave energies and low tide ranges on their flanks, and low wave energies and low tide ranges in their centers. The spatial variability in inlet morphology, therefore, contains information on the relative role of tides and waves in inlet sediment dispersal. The paper concludes by proposing a simple model for inlet morphologies for successively greater relative role of tidal currents in the sediment dispersal. (Authors)

134 **NUMMEDAL, D., FITZGERALD, D.M., and HUMPHRIES, S.M.** 1976. Hydraulics of sediment transportation in mess-tidal inlets (Abs.): Geol. Soc. Amer. Abs. 8(2):236.

Tidal inlets on the largely mesotidal east coast of the United States are known to have ebb-tidal deltas of highly characteristic morphology. Being typically arcuate, the deltas may vary in degree of symmetry, but nearly all display the major morphological components: a main ebb channel, channel-margin linear bars, swash bars, and marginal flood channels.

Continuous sea level gaging combined with seasonal measurements of all relevant hydraulic parameters at two natural inlets on the South Carolina coast, Price Inlet and North Inlet, has produced sufficiently detailed dynamic information to explain the ebb-delta morphology in terms of the hydraulics of sediment transportation and deposition.

It is found that a tidal phase lag exists between the ocean and the marsh creeks. The magnitude of the lag depends on the efficiency of water exchange through the inlet (expressed by the Keulegan repletion coefficient). The phase lag and the associated reduced bay tidal range produce time asymmetry in the inlet current, e.g., the inlet records ebb after the ocean tide has commenced to flood. Because of the diurnal inequality of the tide range and the exchange of part of the tidal prism with other inlet systems behind the barriers, there is generally also a velocity asymmetry present.

The time asymmetry forces the initial flood currents to approach the inlet via the marginal flood channels. Seaward of the flood channels, complex large swash bars are built by refracted waves acting on sediments supplied by longshore currents and the main ebb jet. The channel-margin linear bars are formed by landward-migrating swash bars being truncated by the expanding ebb jet. (Authors)

135 **NUMMEDAL, D., and HUMPHRIES, S.M.** 1978. Hydraulics and dynamics of North Inlet, South Carolina, 1975-76: GITI Rpt. 16, US Army Engineer Waterways Experiment Station, Vicksburg, Mississippi, 213 pp.

North Inlet, South Carolina, was selected as a natural tidal inlet for investigation by the Army Corps of Engineers' program on General Investigations of Tidal Inlets. Over a 2-year period (July 1974-June 1976), eight 2-week intensive field sessions were conducted at the inlet. Three tide gages provided nearly continuous water-surface elevation records for the ocean and tidal creeks. The analysis presented in this report focuses on three attributes of the inlet environment: (1) the inlet hydraulics, (2) the longshore currents adjacent to the inlet, and (3) the seasonal morphologic change of the North Inlet tidal-deltas and adjacent beaches. For the throat section, the peak ebb velocity exceeded the peak flood by a factor of 1.22. The model presented to account for this difference explains the ebb dominance as a result of the different efficiency of water exchange between the ocean and the bay at high and low tides. The longshore currents off Debidue Island were significantly controlled by the wind stress. In a multiple stepwise regression procedure, the longshore component of wind velocity explained more of the variance in the observed longshore current velocity than any other measured environmental parameter. Topograhic mapping of inlet shoals and adjacent beaches, and bathymetric profiling of the throat and the major channels suggest that there is a sediment exchange between the channels and the beaches. During periods of fair weather, the beaches accrete and the channels scour. During high-energy conditions, the reverse occurs. (Authors)

136 **NUMMEDAL, D., OERTEL, G.F., HUBBARD, D.K., and HINE, A.C.** 1977. Tidal inlet variability - Cape Hatteras to Cape Canaveral: Coastal Sediments '77, 5th Sym. of the Waterway, Port, Coas. and Ocean Div., Proc. Amer. Soc. Civ. Engr., 543-562 pp.

Tidal inlets on the southeast coast of the United States are described in terms of morphological characteristics of the shoals and throat section. A distinct geographic zonation is found to exist: in North Carolina and northern South Carolina the inlets have developed both inner and outer shoals (flood and ebb-tidal deltas). In southern South Carolina and Georgia the tidal inlets have developed large outer shoals, while inner shoals are largely absent. The north Florida inlets resemble those in northern South Carolina.

Physical environmental parameters, known to control tidal inlet sedimentation and system boundary conditions, also vary within the same region. These include: tidal range, deepwater wave energy, inner shelf slope, and the percentage of open water in the lagoon.

This paper identifies the major mechanisms which control sediment dispersal and deposition at tidal inlets. These are found to favor landward directed transport through the throat in wave dominated microtidal environments, and seaward transport through the throat in tide dominated environments. (Authors)

137 **NUMMEDAL, D., and PENLAND, P.S.** 1982. Morphology and sediment dynamics of the East Frisian tidal inlets, West Germany: Louisiana State Univ., Baton Rouge, Dept. of Geol., Rpt. No. TR-I; TR-4, 98 pp.

This final report summarizes the results of field investigations along the German North Sea coast performed through support from the Office of Naval Research during the summers of 1978 and 1979. The investigated coastline, the East Frisian Islands, is composed of a series of barrier islands separated by large and deep tidal inlets. The wave energy is high (compared to the barrier island coastline of the eastern United States) and the tide range is about 2.5 m. Tidal inlets represent perhaps the most dynamic of all coastal and shallow marine environments. To the navigator this implies continuously shifting channels and shoals, and to the beach developer or property owner it implies great uncertainty about future shoreline positions. To the geologists the tidal inlets represent major sediment sinks in the littoral transport system, sinks which may account for a significant percentage of the sandy components of shallow marine facies in the rock record. Investigation of sediment dynamics in the East Frisian inlet was undertaken with the objective of understanding the pattern of sediment bypassing of the inlet from updrift to downdrift shores. Only if this could be determined in detail would it be possible to predict, with adequate precision, the migration of navigation channels, the patterns of erosion and deposition on adjacent shores, and the sedimentary facies of the inlet fill itself. (NTIS Abs.)

O

138 **O'BRIEN, M.P.** 1976. Notes on tidal inlets on sandy shores: GITI Rpt. 5, US Army Engineer Waterways Experiment Station, Vicksburg, Mississippi, 30 pp.

This report presents observations, theories, and analysis that the author has found applicable to the rational design of coastal inlets. It also presents various memoranda on the behavior and sedimentary and hydraulic characteristics of tidal inlets on sandy shorelines, and is intended to represent a source of ideas of graduate thesis studies, as well as a stimulant to other research workers in this field. (Author)

139 **O'BRIEN, M.P., and CLARK, R.R.** 1973. Hydraulic constants of tidal entrances 1: Data from NOS Tide Tables, Current Tables, and Navigation Charts: Tech. Rpt. No. 21, Coas. and Oceano. Engr. Lab., Univ. of Florida, Gainesville, Florida, 47 pp.

Methods used in analyzing flow through tidal entrances on sandy coasts make assumptions regarding the geometry of the inlets and related flow regime, which depart substantially from flow conditions at real entrances. A volume of reduced data on tides, currents, and the geometry of tidal entrances is contained in the Tide Tables, Tidal Current Tables, and Navigation Charts of National Ocean Survey. The described approach makes use of these data to characterize the flow in real inlets by means of empirical coefficients which are defined by a simple flow relationship.

The evaluation of the published data pertaining to the hydraulics of entrances indicates that the data are sufficiently accurate and representative, despite some yet unexplained discrepanices, to permit the determination of discharge coefficients of inlets, and to identify categories of entrances with characteristic flow regimes. (Authors)

140 **O'BRIEN, M.P., and HON, M.** 1980. Comments on tidal entrances on sandy coasts: Conf. Coas. Engr., 17th, Proc., 2504-2516.

The paper includes an analysis of some of the physiographic and hydrodynamic relationships which have been developed for tidal inlets. A discussion of several generalized equations for inlet flow area versus tidal prism and tidal discharge is included. Equations relating hydraulic characteristics of ocean, inlet, and bay systems are evaluated, and several techniques for predicting the stability of inlet channels are discussed. Also included is an analysis of the parameters required to forecast tidal inlet closure. (Fields)

141 **O'CONNER, B.A., and LEAN, G.H.** 1977. Estimation of siltation in dredged channels in open situations: 24th Int. Nav. Congr., P.I.A.N.C. Sec. II, Subj. 2, 163-177.

Many engineering problems require the use of dredgers and involve the deepening and realignment of existing seabed channels. For example, many ports and harbors around the world have had to deepen their approach channels to cope with the ever-increasing size of bulk carriers. Similarly, engineering works involving sea outfalls, oil pipelines, and tunnel construction often require the dredging of seabed trenches prior to construction and these must remain open for a period of many weeks or months. The siting of a new port or harbor may also require the provision of a new sea access channel which, in turn, may also require maintenance dredging. Clearly problems such as those described above require the estimation of the rate of sediment infill to a dredged channel under various traffic, tide, and weather conditions.

The alignment of dredged channels is also important from the infill point of view since channels dredged at an angle to the main directions of sediment movement can trap a large proportion of the sediment approaching them. Angled channels may also exhibit a tendency to wander about if large spatial variations in sediment movement occur in the channel vicinity.

The present paper attempts to review some of the methods already suggested for calculating infill rates in dredged channels and to show how the various methods can be deducted from the basic equations describing the flow system. The accuracy of some of the methods is also compared with laboratory results while a further set of laboratory tests is used to demonstrate the importance of channel alignment and in particular to show that infill rates may be minimized by dredging the channel at a small angle to the flow. The future possibility of using numerical computer solutions for two- and three-dimensional channel systems is also indicated. (Authors)

142 **OERTEL, G.F.** 1974. Hydrographic framework of the Doboy Sound Estuary and surveys of the other tidal inlets along the coast of Georgia: NOAA Tech. Rpt. 74-4, 64 pp.

Hydrographic and sedimentologic research was conducted during the summer of 1970 as part of a study to investigate the sediment budget at the entrance of the Doboy Sound Estuary, Georgia. The dynamic diversion of wind, wave, and tidal currents results in a predictable sand-shoal geometry at the entrance of the Doboy Sound estuary. Patterns of diversion developed in response to seasonal fluctuations in wind and wave approach interacting with inlet tidal drains. Mutually evasive flow paths of ebb and flood currents influence the formation of shoals adjacent to inlets. Tidal inlets along the Georgia coast have many hydrographic and geomorphic characteristics in common. Sedimentation occurring in estuaries with large fluvial sources is generally a response to some form of bipolar flow associated with a stratified water mass. The tidal inlets generally have large tidal drains that are diverted by mutually evasive tidal channels and inlet "water piles." (NTIS Abs.)

143 **OERTEL, G.F.** 1977. Geomorphic cycles in ebb deltas and related patterns of shore erosion and accretion. Jour. Sed. Pet., 47(3):1121-1131.

The interrelationship between inlet flow and delta morphology has an important effect upon the bypassing of sediment across inlets. Along the Sea Island Section of the Coastal Plain Physiographic Province the nature of inlet drainage and sediment bypassing profoundly influences patterns of beach erosion and accretion.

Small coastal plain inlets generally have arcuate ebb deltas transected by a radially distributed pattern of channels. This arrangement permits an efficient flow of sediment across the inlet with little disturbance to the sediment budget of the adjacent shorelines.

Several small inlets also have spits parallel to the shore that divert the flow of river water into the downdrift shore causing erosion. Accretion at the distal ends of these spits takes place at the expense of the proximal end of the spit where the shorelines erode. Erosion eventually reopens a new channel across the proximal end of the spit and produces a second drainage reentrant.

The major inlets along the coastal plain shoreline exhibit shoals with pronounced shore-normal orientations. The proximal ends of these spits may be attached or separated from the shore. When spits are attached to the shore, erosion is observed along the inlet margin and deposition is apparent at the distal end of the spit. When spits are separated from the shore, accretion is observed at shores adjacent to the inlet. (Author)

144 **OERTEL, G.F., and HOWARD, J.D.** 1972. Water circulation and sedimentation at estuary entrances on the Georgia coast: Swift, D.J.P., Duane, D.B., and Pilkey, O.H. eds., Shelf Sediment Transport: Dowden Hutchinson and Ross, Stroudsburg, Pa, 411-427.

Estuary entrance-shoals extend seaward of all major entrances of the Georgia coast. Orientation and morphology of these shoals occur in response to (a) transient coastal currents controlled by seasonal winds, (b) the relative magnitude of ebb jets to coastal currents, and (c) hydraulic pressure gradients at entrances.

Northeasterly winds create high-energy swells which result in a southward diversion of longshore drift and a southeast aggradation of shoals on the north sides of inlets. These shoals are detached from the shoreline and are generally breached in several places by small tidal channels. Attached shoals on the south sides of inlets are sediment starved during these periods.

Southerly onshore winds result in currents which cause a seaward prograding of shoals on the south sides of inlets. At the same time, sediment cells and gyres trap sediment on shoals on the north sides of inlets and accretion is multidirectional. (Authors)

145 **OLSEN, E.J.** 1977. A study of the effects of inlet stabilization at St. Marys Entrance, Florida: Coastal Sediment '77, 5th Sym. of the Waterway, Port, Coas. and Ocean Div., Proc. Amer. Soc. Civ. Engr., 311-329.

The stablization of any naturally functioning inlet by dredging and/or the construction of jetties dramatically modifies the hydraulics of the prior regime, and therefore upsets the long-term "dynamic equilibrium" previously in existence. The consequence is the initiation of a new balance between hydraulic and sedimentary forces which causes a reconfiguration of ocean shoal formations and adjacent shorelines.

This paper presents the results of a coastal engineering study evaluating the performance of the Federal navigation project at Fernandina Harbor, Florida, with a view to determining the extent to which the adjacent ocean shores have been affected since commencement of the original project improvements in 1881.

Through computerized comparisons of post- and prestabilization hydrographic data, the study found that the ocean shoal eastward of St. Marys Entrance has changed extensively due to the alteration of the hydromechanics of the jettied inlet. Correspondingly, very large volumes of sand have been transported from the nearshore littoral regime to deeper waters to proximate the terminus of the rubble-mound structures. Of significant interest has been the response of the coastline for appreciable distances both north and south of the inlet. As the original equilibrium ocean shoal formation collapsed and underwent redistribution, severe shoreline recession and erosion has occurred along adjacent beaches resulting in losses of both real estate and structures, particularly at Fernandina Beach, Florida. (Author)

146 **ONYSKO, S.** 1979. Chatham Bars Inlet: Cape Cod Massachusetts: Coastal Structures '79, Proc. Amer. Soc. Civ. Engr., 2:710-728.

The first recorded shipwreck in the new world was in an inlet through Nauset Beach on Cape Cod, Massachusetts, in 1626. Since that time, the inlet has undergone at least two and possibly three cycles of large-scale migration. This paper shows some of the historical inlet changes and describes a number of alternative plans to assist nature in forming an inlet through the barrier beach at a location that would mitigrate future potential ecological and environmental problems. (Author)

147 **OZSOY, E.** 1977. Flow and mass transport in the vicinity of tidal inlets: Rpt. No. UFL/COEL/TR-036, Coas. and Oceano. Engr. Lab., Univ. of Florida, 196 pp.

The flow and mass transport associated with turbulent jets ebbing from tidal inlets are analyzed by including the effects of frictional resistance and topographic variations of the bottom, ambient cross currents and concentrations, and settling to the bottom. The retardation of the jet due to bottom friction results in a rapid expansion that is considerably faster than in the case of a classical jet. An offshore-sloping bottom topography opposes this effect. Dilution within the jet is suppressed due to friction, and enhanced by an offshore-sloping bottom. In the case of sediments, finer sediments are transported to farther offshore as compared to coarser sediments. Largest depositions occur near margional shoals. Deep scouring may occur near the mouth region at times of extreme flows. These results and their implications on the geomorphology near tidal inlets and river mouths are discussed. Exchange and mixing mechanisms of bays are studied, based on these results and the unsteady development of tidal jets described. (Author)

148 **OZSOY, E.** 1977. Flow separation and related phenomena at tidal inlets: Ph.D. dissertation, Univ. of Florida, Engr. Sci. Dept., 346 pp.

Various phenomena associated with flow separation at tidal inlets and other narrow entrances are analyzed. The solutions are then used in discussing relevant applications.

In Part I, flow and mass transport are analyzed for turbulent jets issuing from tidal inlets during the ebbing phase. Frictional resistance and topographical variations of the bottom and ambient cross currents are taken into account. In studying mass transport, settling of materials to the bottom and ambient concentrations are also allowed.

The flow is analogous to that of a classical two-dimensional turbulent jet when bottom friction and topographical variations are neglected; and the solutions compare favorably with available theories. When bottom friction is present, the jet expands rapidly and gets retarded. Effects due to an offshore-sloping bottom counteract the rapid expansion due to friction. For arbitrary depth variations, the jet may go through a series of expansions and contractions with distance. Comparing these solutions with experimental and field evidence gives satisfactory results. In the case of pollutants, bottom friction reduces dilution within the jet due to a decrease in convective transport. An offshore sloping bottom opposes this effect. The transport of suspended sediments depends on the fall velocity of sediments and the velocity at the inlet, in addition to bottom friction and depth variations. Finer sediments are transported to larger distances offshore as compared to coarser sediments. The largest deposition occurs at the location of two marginal shoals flanking the jet center line. When the velocity at the inlet exceeds a critical value, deep scour holes are formed near the inlet mouth. These results and their implications on the geomorphology near tidal inlets and river mouths are discussed qualitatively.

Exchange and mixing in a bay-inlet-ocean system is studied, based on the results of the previous analysis. Materials within the bay are jetted to great distances offshore during the ebbing phase and this provides an efficient flushing mechanism.

Finally, the unsteady development of a tidal jet is described qualitatively and a simple method for calculating the speed of the jet front is proposed. Preliminary experiments are also provided.

In Part II, an experimental approach is used in determining the wave scattering by narrow openings such as tidal inlets, tsunami breakwaters, and harbor entrances. Flow separation and generation of jets and vortices in the near field of the opening determines the subsequent loss of energy and the scattering of waves in the far field.

Approximate methods are used in anlayzing the nonlinear behavior of a narrow opening in the presence of flow separation. Experimental results are interpreted by making use of these approximate solutions.

Experimental procedures are complicated because of the shallow water nonlinearity, which causes the incident waves to be almost periodic in space and to have harmonic distortion. Therefore, the measured wave forms are Fourier analyzed and the spatial amplitude variations of the incident and reflected harmonics are obtained.

The transmission of waves is reduced by two main factors; one being due to the inertial reactance resulting from the disturbance of the flow by opening, and the other being due to the drag resistance caused by flow separation. When inertial reactance is dominant, the response is selective of frequency; whereas, when separation resistance is the dominating factor, wave transmission becomes dependent on amplitude only. The dissipation of energy is maximal in the second case.

It is also shown that the scattering of the fundamental component is not affected significantly by the presence of higher harmonics in the incident wave. However, the same result is not true for the scattering of higher harmonics. (Author)

149 **OZSOY, E.** 1977. Suspended sediment transport near tidal inlets: Coastal Sediments '77, 5th Sym. of the Waterway, Port, Coas. and Ocean Div., Proc. Amer. Soc. Civ. Engr., 914-926.

Jet diffusion and settling of suspended sediments in the vicinity of tidal inlets are analyzed. Bottom friction retards the jet and therefore causes an increase in the deposition rate; however, an offshore sloping bottom opposes this effect. Bottom sediments are sorted with respect to grain size. Large depositions occur where marignal shoals are usually found. For high inlet velocities, erosion near the mouth generates deep troughs due to scouring. These results and their implications on the geomorphology of the inlet vicinity are discussed qualitatively. (Author)

P

150 **PENLAND, S.** 1979. *Influence of a jetty system on tidal inlet stability and morphology: Fort George Inlet, Florida: Coastal Structures '79, Proc. Amer. Soc. Civ. Engr., 2:665-689.*

Fort George Inlet is located in northeastern Florida, 0.9 km north of the St. Johns River. Since the construction of jetties (1881-1902), the geomorphic history of Fort George Inlet has been characterized by instability and migration.

Prior to jetty construction, Fort George Inlet was located 4.2 km north of the St. Johns River and was stable; drift material bypassed it in a southward direction. In contrast, the channel of the St. Johns River was unstable. A 25-year cycle of channel migration was recognized by local bar pilots. The channel would migrate southeast until it became shallow and inefficient. A more efficient channel would then break through the bar to the north, initiating another cycle of migration. Jetties were constructed to stabilize and maintain a navigable channel at the St. Johns River.

Morphologic changes at Fort George Inlet, initiated by the jetties, were determined utilizing beach profiles established in 1923 in conjunction with air photos, hydrographic surveys, and historical maps. The present pattern of sediment dispersal in Fort George Inlet was determined through correlation of fluorescent tracer dispersal, bed-form orientations, and inlet morphology.

Since jetty construction, southerly littoral drift (270,000 m^3/yr) has been partially intercepted and deposited along Little Talbot Island and the flank of the northern jetty. Accretion and expansion of Little Talbot Island forced Fort George Inlet to migrate south. However, in 1924, the direction of inlet migration was reversed and is now northward. It is inferred that wave reflection from the north jetty is responsible for this migration reversal. Morphologically, the northward channel migration is accompanied by the development of a recurved spit, Wards Bank, extending north from the northern St. Johns River jetty. Sediment eroded from Little Talbot Island provides the material for nourishment of this spit. (Author)

151 **PERRY, F.C., SEABERGH, W.C., and LANE, E.F.** 1978. Improvements for Murrells Inlet South Carolina: Tech. Rpt. H-78-4, US Army Engineer Waterways Experiment Station, Vicksburg, Mississippi, 339 pp.

Murrells Inlet, located 13 miles southwest of Myrtle Beach, South Carolina, is a natural channel through a sandy beachline that conducts tidal flows between the Atlantic Ocean and a well-mixed lagoon of ocean salinity which has no source of freshwater inflow other than local surface runoff. The inlet provides passage from the ocean to docking facilities for charter craft, commerical fishing vessels, and private boats. However, due to the influx of sand into the inlet, an environment of shallow shifting-sand shoals and breaking waves produces difficult and dangerous navigation conditions.

A project for the improvement and stabilization of the inlet was authorized in November 1971. A model study was performed to aid in preconstruction planning and design of structural solutions to the problem of providing a stabilized channel of sufficient depth and width with provisions for sand bypassing.

The Murrells Inlet fixed-bed model, constructed of concrete to scales of 1:200 horizontally and 1:60 vertically, accurately reproduced the lagoon and a region of the ocean near the inlet, an area of approximately 14.2 square miles. After a least-squares harmonic analysis of prototype tidal data for amplitude and phase of various tidal constituents, a successful hydraulic model verification was made based on the M_2 constituent.

The model study examined a variety of plans in order to optimize the alignment and spacing of jetties and the proper alignment of interior channels with respect to current patterns. Also, the effects of the plans on bay tidal elevations and tidal currents were determined as were the effects on wave heights.

Model testing concluded that plan 1H was the optimal plan for providing a stable entrance channel while providing for sand bypassing. The plan included:

a. A north quarrystone jetty composed of a 1,330-ft-long low weir section constructed to a +2.2 ft mlw elevation flanked by a 1,505-ft-long seaward section and a 518-ft-long shoreward section, each with a top elevation of +9.0 ft mlw.

b. A 3,330-ft-long south quarrystone jetty with a top elevation of +9 ft mlw. Also an 8-ft-wide fishing walkway will be constructed on the crest of the south jetty to el +10 ft mlw.

c. Sand dikes connecting the shoreward ends of the jetties to the dune line.

d. A 20-ft-deep deposition basin of 600,000-cu-yd capacity dredged adjacent to the low weir section on the inlet side.

e. A 300-ft-wide by 10-ft-deep entrance channel.

f. A 200-ft-wide, 10-ft-deep inner channel connecting the entrance channel to the mouth of Main Creek, where it joins a 90-ft-wide, 8-ft-deep channel that extends 13,590 ft to the Army Crash Boat Dock.

g. A 200-ft-wide, 10-ft-deep auxiliary channel connecting the entrance channel to the mouth of Oak Creek.

h. A training dike of variable height which flanks the lagoon side of the deposition basin in order to prevent tidal currents from passing through the basin.

The plan would not have a significant impact on tidal conditions, with maximum changes of 0.3 ft in bay tidal amplitudes, 0.2 ft in mean tide level, and 11 min in tidal phasing. Also there would be no significant change to the inlet's tidal prism. (Authors)

152 **PRATHER, S.H., and SORENSEN, R.M.** 1972. A field investigation of Rollover Fish Pass, Bolivar Peninsula, Texas: Texas A&M Univ., College Station, Coas. and Ocean Engr. Div., Rpt. No. TAMU-SG-72-202, 126 pp.

A field study of Rollover Fish Pass, anrtificial tidal inlet connecting Galveston East Bay, Texas, with the Gulf of Mexico, was conducted. The objectives of this study were, (1) to evaluate the flow and stability characteristics of the inlet, (2) to investigate the propagation of the tidal wave through the connected bay system, and (3) to evaluate the effect of the inlet on tidal fluctuations and flushing of East Bay. Fieldwork included hydrograhic surveys of the inlet and adjacent Gulf beaches, collection and analysis of sediment samples from the inlet and beaches, measurement of tidal fluctuations at selected locations in East Bay, and current measurements in the inlet. Tidal data from the Gulf, provided by the Galveston District, Corps of Engineers, were analyzed along with the field data. (Authors)

R

153 **REDDERING, J.S.V.** 1983. An inlet sequence produced by migration of a small microtidal inlet against longshore drift: The Keurbooms Inlet, South Africa: Sedimentology, 30:201-218.

Lateral migration of the Keurbooms Inlet along its barrier causes stratigraphic stacking of the different sedimentary units in the inlet area thus accumulating an inlet sequence under the newly formed barrier. Deposition in the inlet is controlled by wave and tidal action. Migration is caused by sediment accretion on the downdrift side of the inlet and erosion on its updrift side. The migration direction is therefore in the opposite direction to the longshore current. This is comparatively rare as most inlets with a tendency to migrate do so in the same direction as longshore drift. Tidal current directions in the inlet are highly variable and not bipolar.

The inlet-associated environment is divided into a seaward wave-dominated zone and a landward tide-dominated zone. These zones probably have laterally interfingering facies. Only the lower part of the sequence is likely to be preserved. Recognition of ancient analogues in the rock record may be obscured by the unidirectional palaeocurrent pattern of the lower part of the inlet sequence. (Author)

154 **REINSON, G.E.** 1977. Tidal-current control of submarine morphology at the mouth of the Miramichi Estuary, New Brunswick: Can. Jour. of Earth Sci., 14(11):2524-2532.

The mouth of the microtidal Miramichi Estuary, New Brunswick, is enclosed by a barrier-island system which is cut by two major tidal inlets. The submarine morphology adjacent to these inlets indicates the presence of large tidal deltas which formed predominantly by tidal-current processes. The extensive shoal water on the landward side of the barrier is due to the landward transport of sand through the inlets and the deposition of this sand as coalescing flood-tidal delta deposits. The creation of an artificial channel inside the main inlet in the late 19th century, and its maintenance since that time, have resulted in substantial channel-flow bypassing of the natural channel seaward of the barrier. This promoted the scouring of a new channel through the ebb-tidal delta shoal.

Large tidal deltas apparently are not common morphological features of estuaries on microtidal, barrier-island coastlines, but they do occur at the entrances of very large microtidal estuaries such as the Miramichi. In such cases they are usually completely subtidal, and much larger than tidal deltas of mesotidal estuaries reported in the literature. Rather than tidal range, the tidal prism, which takes into account both tidal range and estuary surface area, may play the major role in the formation of tidal deltas in both meso-tidal and microtidal estuaries. (Author)

155 **RENGER, E.** 1978. Two-dimensional stability analysis of tidal basins and tidal flats of larger extent: Conf. Coas. Engr., 16th, Proc., 1971-1985..

Stability studies of natural tidal basin system demand a regime-oriented analysis and a characteristic quantification of the morphologic values. Hence it was necessary to create relative form parameterization dependent on the location by means of a two-dimensional system of natural coordinates (z = elevation, s = gully length coordinate).

The underlying logic for the determination of the equilibrium of the tidal basins and tidal flats is as follows: When the continuity equation for nonsteady flow at any cross section (s_i, z_i) of a tidal basin, within the mean tidal range is applied, a dimensionless relationship between horizontal and vertical cross sections (A and F) and tide-generated mean velocities of current (±u) and tidal rise and fall (±v) can be derived with an accuracy of more than 90 percent:

$$\frac{u}{v} \simeq \frac{A}{F}$$

The analysis of the term on the right-hand side of this equation showed a characteristic vertical distribution of the relationship for all investigated tidal basins of the German Bight and look rather similar. The reference values of the corresponding relationships depend on the area of the tidal basin (E) at MHW and the mean tidal range (H).

The influence of the horizontal extent has been elaborated by varying the line of intersection systematically along the gully-length-coordinate (s). In addition, it was possible to point out the differences between the characteristics of stable and (well-known) nonstable conditions by means of a two-dimensional analysis of the dammed-off tidal river EIDER/German Bight.

The relations derived may prove to be useful in the planning of future constructions and even in understanding and influencing the disadvantageous changes in running systems. (Author)

156 **RENGER, E., and PARTENSCKY, H.W.** 1980. Sedimentation processes in tidal channels and tidal basins caused by artificial constructions: Conf. Coas. Engr., 17th, Proc., 2481-2494.

The author presents two empirical approaches which can be used to predict changes in morphology and expected sedimentation rates in tidal systems altered by man-made constructions. The first approach developed by Hensen (1937), relates the average flood current velocity to changes in morphologic parameters of mean tidal prism, duration of flood, and mean cross-sectional area. A more detailed relationship described by Renger (1978), defines the mean current velocity in terms of the horizontal and vertical cross sections, and the mean velocity of tidal rise and fall. Using the two different regime relationships, the author distinguishes between four stages of morphologic development in tidal basins affected by man-made construction. Finally, sedimentation rates are determined from the tidal prism values predicted by each of the methods. Prototype measurements from the Eider River, Germany indicate that the observed sedimentation rates are in good agreement with the theoretical values calculated by the two approaches. (Fields)

157 **RIEDEL, H.P., and GOURLAY, M.R.** 1977. Inlets/estuaries discharging into sheltered waters: Coastal Sediments '77, 5th Sym. of the Waterway, Port, Coas. and Ocean Div., Proc. Amer. Soc. Civ. Engr., 2550-2564.

Tidal prism-cross-sectional area relationships and tidal velocities have been measured for inlet entrances and along the length of the estuary for four creeks entering the sheltered waters on the South East Queensland coast, Australia. It has been found that the inlet entrance tidal prism-cross-sectional area relationship is controlled by the magnitude of littoral drift. The tidal prism-cross-sectional area relationship along the estuary is believed to be common to all tidal estuaries landward of the region where littoral drift has an influence.

For tidal inlets on sheltered coasts with tidal prisms of the order of 10^6 m^3, the mean maximum velocity during spring tides at the inlet entrance is about 0.3 to 0.4 m/s. (Authors)

158 **RIGGENBACK, D.K.** 1976. The effects of dredging on the stability of an ebb-tidal delta, Lynnhaven Inlet, Virginia: M.S. Thesis, Old Dominion Univ., Norfolk, Virginia, 112 pp.

A channel was dredged in 1965 through the ebb-tidal delta of Lynnhaven Inlet, Virginia. The purpose of this study was to determine if this channel has affected the morphological configuration of the delta. It was proposed that the channel caused the dynamically stable delta to become unstable and change its morphology.

Bathymetric comparisons of seven surveys during the last 122 years, including one conducted during this investigation, show that prior to 1926 and the dredging operations, the delta had become dynamically stable. The present survey shows that the delta has changed its shape in response to the interaction of the channel and the currents moving through the area. Since dredging began, depths over the delta have increased and the delta is shrinking.

Measurements of reversing tidal currents moving through the area indicate that they are great enough to move bottom material and enact the sediment transport. Mean grain-size analysis indicates that the distribution of the sediments in the area is a response to the tidal currents. (Author)

𝒮

159 **SAGER, R.A., and SEABERGH, W.C.** 1977. Comparison of numerical and physical hydraulic models, Masonboro Inlet, North Carolina; Appendix 1: Fixed-bed Hydraulic Model Results: GITI Rpt. 6, US Army Engineer Waterways Experiment Station, Vicksburg, Mississippi, 69 pp.

This appendix discusses the verification, base tests, and predictive test of a fixed-bed hydraulic model of Masonboro Inlet, North Carolina, as part of the evaluation of the state-of-the-art inlet modeling techniques. It presents the data necessary for a comparison of results of the physical and numerical models discussed in the basic report and in the following appendixes.

a. Appendix 2. F.D. Masch, R.J. Brandes, and J. U. Reagan, "Numerical Simulation of Hydrodynamics (WRE)."

b. Appendix 3. R.M. Chen and L.A. Hembree, "Numerical Simulation of Hydrodynamics (TRACOR)."

c. Appendix 4. C.J. Huval and G.L. Wintergerst, "Simplified Numerical (Lumped Parameter) Simulation." (Authors)

160 **SAGER, R.A., and SEABERGH, W.C.** 1977. Physical model simulation of the hydraulics of Masonboro Inlet, North Carolina: GITI Rpt. 15, US Army Engineer Waterways Experiment Station, Vicksburg, Mississippi, 258 pp.

This report is part of the General Investigation of Tidal Inlets "Inlet Hydraulics Study." The study involves the investigation of the tide- and wave-generated flow regime and water-level fluctuations in the vicinity of coastal inlets. Masonboro Inlet was selected as an inlet to be used in determining the usefulness and reliability of physical and mathematic models in prediciting hydraulic characteristics of inlet/bay systems. This report presents results obtained from the physical model study.

The Masonboro Inlet fixed-bed model, constructed to scales of 1:300 horizontally and 1:60 vertically, reproduced an area extending to the -45 ft contour in the Atlantic Ocean and to the nodal points in each interior channel. The wetlands were accurately reproduced near the inlet; but those areas farther bayward, being relatively flat, were reproduced schematically and artificially bent into the research flume to provide storage for the tidal prism. The model was equipped with appurtenances necessary for accurate reproduction and measurement of tides, tidal currents, waves, and other significant prototype phenomena. Model verification tests assured that the model hydraulic regimen was in satisfactory agreement with that of the prototype. Five velocity ranges with three stations at each range were verified in the model (readings were taken at three depths at each station); and seven tidal elevation gages in the ocean and bay were also verified.

A detailed examination of the effects of waves on model current and tidal height data was then made. A circulation pattern was set up in the lee of the single jetty which ebbed out along the edge of the jetty, then returned along the outer portion of the ocean bar back toward shore and the inlet.

This occurred for a variety of wave directions. Waves approaching from a S16 deg E direction, directly into the ebb current, produced the greatest effect on tidal heights in the bay, causing a superrelevation of the heights when compared with data taken without waves.

After testing the 1969 condition, the model was remolded to the November 1964 condition, which represents a time preceding the construction of improvements--a north jetty, a deposition basin, and a dredged channel. Base data were collected, then the improvements were installed upon this condition and tests were run to predict the effect of the improvements on the tidal elevations, tidal currents, and wave-induced currents. The model was then remolded to the July 1966 postconstruction condition and tests were conducted to gather data to compare with the predicted data since no immediate prototype postconstruction hydraulic data were available.

The fixed-bed model predictions of a filling of the dredged navigation channel, filling of the deposition basin, and a tendency of the navigation channel to shift toward the north jetty were substantiated by comparison with the 1966 model results and with prototype data. (Authors)

161 **SARLE, L.L.** 1977. Processes and resulting morphology of sand deposits within Beaufort Inlet, Carteret County, North Carolina: M.S. Thesis, Duke Univ., Durham, North Carolina.

Physical processes active within Beaufort Inlet control the existing pattern of erosion and deposition. A temporal (1-hr lag) and tidal range amplitude difference between Back Sound and the Atlantic Ocean results in time-velocity asymmetry and tidal current segregation. Time-velocity asymmetry causes the shallower shielded zone in Back Sound to be flood-dominated. Landward migrating sandwaves (up to 2.5 m/day), welding bars, seaward accreting beach crests, and estuarine spit growth indicate net landward transport. Sediment transported landward by tidal currents and waves accumulates on the beaches and flood-tidal deltas. These tidal deltas conform to the flood-tidal delta model of Hayes et al. (1973) consisting of flood ramps, ebb shields, ebb spits, and ebb spillover lobes.

Tidal-current velocities in Beaufort Inlet have increased from approximately 75 cm/sec in 1960 to 115 cm/sec in 1976. This increase in tidal current velocities resulted from the narrowing of Beaufort Inlet by the stabilization of Fort Macon Point, shoaling of the flood-tidal delta, and the westward migration of the Shackleford Spit. Tidal-current velocities are highest at the inlet throat and decrease with distance from the inlet. An increase in tidal-current velocities is observed with a change from neap to spring tides.

Sediments carried seaward by strong ebb-tidal currents accumulate on a deepwater, asymmetrically shaped ebb-tidal delta consisting of a terminal lobe, uneven marginal flood channels, a main ebb channel, and channel-margin linear shoals. Segregation of flood-tidal currents to the western side of Beaufort Inlet, during the ebb lag in the main channel, augments the shoaling effects of southwest waves there. This extensive shoaling on the western side of the inlet causes the ebb channel to migrate and erode the tip of the Shackleford spit. Prior to this recent erosion (30 m since 1971), the Shackleford spit was a site of deposition. The 900-m spit growth between 1953 and 1962 was primarily the result of hurricane storm deposits. The 380-m spit growth between 1962 and 1965 was the result of the attachment of a flood-tidal delta and subsequent beach ridge accretion on the flood-tidal delta base. The slower rate of spit growth (6 m/year) between 1965 and 1971 is the result of fair-weather, inlet sediment-trapping processes.

The incorporation of the flood-tidal delta into the Shackleford Spit and the dual function of the ebb-tidal delta as a sediment sink during fair weather, and as a sediment source during storms, demonstrate the importance of inlet sand bodies to barrier island equilibrium. (Author)

162 **SCHMELTZ, E.J., and SORENSON, R.M.** 1973. A review of the characteristics, behavior and design requirements of Texas Gulf Coast tidal inlets: Texas A&M Univ., College Station, Coas. and Ocean Engr. Div., Rpt. No. TAMU-SG-73-202, 99 pp.

The paper is intended to provide the reader with a background in the design of tidal inlets. In order to adequately achieve this end, an effort is made to present the hydraulic equations generally used to describe the flow in a tidal inlet along with an explanation of the simplifying assumptions normally made. Consequences of these assumptions as well as relative sizes of the terms deemed negligible are included. Consideration is given to the response of tidal inlets to such outside influences as wave action, littoral drift and tides. Presently accepted methods for determination on inlet stability are included, and the necessary parameters for an effective inlet design are presented. Materials on specific topics are listed under categories deemed appropriate by the writers. (Authors)

163 **SCHMELTZ, E.J., SORENSEN, R.M., McCARTHY, M.J, and NERSESLAN, G.** 1982. Beach/inlet interaction at Moriches Inlet: Conf. Coas. Engr., 18th, Proc., 1062-1077.

Moriches Inlet is located on the south shore of Long Island, New York, approximately 45 miles (72 km) west of Montauk Point and 80 miles (130 km) east of New York City. The inlet forms the primary outlet through the barrier island between Moriches Bay and the Atlantic Ocean. The inlet is protected and stabilized by two stone jetties approximately 800 ft (245 m) apart.

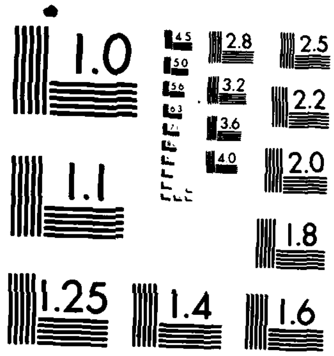
During January 1980, a severe northeast storm resulted in the breaching of the barrier island immediately to the east of the existing Moriches Inlet. By the fall of 1980, the breach had expanded to nominally 2,900 ft (885 m) in width with a maximum depth of around 10 ft (3 m) and the US Army Corps of Engineers was requested to effect its closure. The method adopted by the Corps consisted of the placement of beach fill in the opening to develop a cross section with a center-line elevation of +13.25 ft (4 m) mlw and side slopes of 1V:25H. Initiated in October 1980, the closure operation was successfully completed in February 1981.

The formation of a significant breach immediately adjacent to the existing inlet and the artificial closure of the opening afforded a unique opportunity to study the dynamics of a tidal inlet under the influence of relatively rapid changes in tidal prism and cross-sectional area. The purpose of this paper is to present the results of a field measurement program and subsequent analyses of the dynamics of the inlet/breach system. The analyses were based on data obtained before, during, and after closure of the breach. (Authors)

AD-A161 548 ANNOTATED BIBLIOGRAPHY OF SEDIMENT TRANSPORT OCCURRING OVER EBB-TIDAL DELTAS(U) ARMY ENGINEER WATERWAYS EXPERIMENT STATION VICKSBURG MS GEOTE 2/2

UNCLASSIFIED L L WEISHAR ET AL SEP 85 WES/MP/CERC-85-11 F/G 8/3 NL

END



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

164 **SEABERGH, W.C.** 1979. Model testing of structures at a tidal inlet: Coastal Structures '79, Proc. Amer. Soc. Civ. Engr., 2:690-709.

During the course of a model study of Masonboro Inlet which was part of the Corps of Engineers General Investigation of Tidal Inlets research program, a variety of structural changes to the inlet region were examined. One series of tests concerned the closure of bay channels. The bay system of Masonboro Inlet is composed of three distinct channels which diverge from the inlet's gorge. The tests were designed to investigate the effect of closing one of the three channels on the tidal hydraulics for each of the three possible cases. Possible effects on the inlet's morphology were then extrapolated from the model results and for one case were compared to an actual closure condition in the prototype. (Author)

165 **SEABERGH, W.C., and LANE, E.F.** 1977. Improvements for Little River Inlet, South Carolina, Tech. Rpt. 11-77-21, US Army Engineer Waterways Experiment Station, Vicksburg, Mississippi, 298 pp.

Little River Inlet, located near the State border of North and South Carolina, is part of the "Grand Strand," a rapidly growing resort area along South Carolina's northeast shore. The inlet is a natural channel through the coastal barrier beach that conducts tidal flows between the Atlantic Ocean, inner channels, and a lagoon approximately 6 square miles in size. The inlet also provides a restricted passage for small-craft navigation from the ocean to the Atlantic Intracoastal Waterway (AIWW) and to private and commerical docking facilities.

Improvements for the inlet were authorized on 12 October 1972 and included two jetties, sand transition dikes connecting the structures to the shore, a 300-ft-wide by 12-ft-deep entrance channel through the offshore bar, and a 90-ft-wide by 10-ft-deep inner channel from the entrance channel to the AIWW.

A model study was performed to aid in preconstruction planning and design of the structures and included an investigation of items such as optimum alignment, length and spacing of the jetties, current patterns and magnitudes, sediment movement patterns, effects on the tidal prism, and effects on bay salinities.

The Little River Inlet fixed-bed model, constructed of concrete to scales of 1:300 horizontally and 1:60 vertically, reproduced an area extending to the 40-ft contour in the Atlantic Ocean and to the extent of the influence of the tidal prism on the AIWW. Areas throughout the lagoon were accurately reproduced and model verification tests of tidal elevations, velocities, and salinities assured that the model hydraulic regimes were in satisfactory agreement with the prototype.

Model testing concludes that Plan 2D-1 which included weir sections backed by deposition basins for both jetties would be the most feasible plan. The mean tide level weirs would permit sand transport to the basins on flood tide but would prevent ebb flows from existing over them due to the tidal elevation-velocity relations characteristics of Little River Inlet where maximum ebb velocities occur after the tide elevation has fallen below midtide. Also, flow in the entrance channel was ebb-dominant which would aid in flushing sediment out of the channel. The sand-trapping abilities of the deposition basins permitted shortening of the jetties since a large amount of sand fillet storage would not be needed and sand movement around the jetty tips would be minimized. Testing also indicated there would be no significant change to the bay tidal prism or salinities. (Authors)

166 **SEABERGH, W.C., and SAGER, R.A.** 1980. Supplementary tests of Masonboro Inlet fixed-bed model; Hydraulic Model Investigation: GITI Rpt. 18, US Army Engineer Waterways Experiment Station, Vicksburg, Mississippi, 233 pp.

This report describes supplemental tests of the Masonboro Inlet fixed-bed model not reported in "Physical Model Simulation of the Hydraulics of Masonboro Inlet, North Carolina," GITI Report 15. The supplemental tests consist of three separate studies performed in the Masonboro Inlet fixed-bed model. The first study examines the effects of the closing of various bay channels on the inlet's hydraulics. The second study examines the effects of the addition of a south jetty to the existing condition which has a single north jetty and examines the resulting hydraulics for various weir elevations on both jetties. The third study examines the use of a tracer material and closely parallels the hydraulic testing sequence discussed in the previous Masonboro Inlet report. The tracer tests include verification of the 1969-1971 shoaling trends, testing of the prejetty 1964 condition, testing of the single jetty plan with the 1964 bathymetry, and testing of the postjetty construction 1966 condition. These tests were performed to evaluate the effectiveness of using sediment tracer materials in inlet model studies.

Results indicate the closure of any of the three interior channels in Masonboro Inlet produces a significant change in the inlet hydraulics and would most likely produce a significant change in morphology as illustrated by the prototype case history. The important changes in flow patterns at the inlet entrance occur for the ebb flow, with flood flow patterns at the entrance staying fairly constant. Keulegan K values show decreases for each closure condition, with closure of Banks Channel (the largest interior channel) providing the greatest decrease. These decreases in K are the result of a reduction in flow area and an increase in the effective length of the inlet for each closure condition. This in turn increases the bay superelevation because of the reduction in K . Shinn Creek, the interior channel perpendicular to the coast, aids in directing ebb flow oceanward, perpendicular to the coast as seen in evaluating flow volumes through range 1 for the various conditions. This indicates that the initial scour along the outer portion of the north jetty could have been caused by this ebb flow effect. This result must also be coupled with wave effects which probably contributed to filling the dredged channel location.

Weir jetty testing indicated the effect of a south jetty is to centralize the flood flow through the inlet gorge, and the presence of a weir on the south jetty does not change this basic flow pattern. As a result of this flow pattern flow increases through Shinn Creek, the channel directly behind the inlet gorge. Flow velocities over the 0.0-mlw weirs are slightly greater than those over the +2.0 weir jetties (0.2 to 0.4 fps greater). However, the flow volume coming over the 0.0-mlw weir sections is substantially greater, which slightly reduces flow entering between the jetties at their oceanward end. Ebb velocities seem to be better centralized between the jetties for the +2.0 mlw weirs and the nonweir south jetty conditions than for the 0.0-mlw weirs. Flow over the +2.0 mlw weirs cuts off very early during ebb flow since the tide level has dropped to just below the mtl once ebb flow has begun to reach faster velocities. For the 0.0-mlw weir condition, however, ebb flow over the weirs continues until nearly low water. The continued drawndown of ebb flow over the 0.0-mlw weirs aids in dispersing the flow over the entire region between the jetties and seemingly could aid currents to flow along the inner walls of the jetties rather than concentrating in the central region between the jetties where the navigation channel is located. Plan 3 (dual weirs at 0.0 mlw) produced a much greater ebb velocity predominance between the jetties than did plan 2 (dual weirs at +2 mlw).

Results of the sediment traces testing indicate that short-term fill and scour trends can be predicted qualitatively. Also the reduction in model distortion to values less than this study's 5:1-scale distortion would appear to improve fill and scour tests, especially in areas of steep slopes such as the inlet's gorge. (Authors)

167 **SEDWICK, E.A.** 1975. Hyrdaulic constants and stability criterion for MOB Inlet: M.S. Thesis, Coas. and Oceano. Engr. Lab., Univ. of Florida, Gainesville, Florida, 43 pp.

O'Brien Lagoon is a beach feature at the northern end of Treasure Island, Florida, with a surface area of 9.1×10^5 ft^2. MOB Inlet connects the lagoon to the Gulf of Mexico. This study is an analysis of the hydrographic data collected at the location during fall of 1973 and winter of 1974.

The collected data have been used to calibrate a computer model for calculating the currents through the inlet and tidal variation in the lagoon. The output from the model has been used to calculate the tidal prism and other hydraulic constants. These have been plotted against the Keulgan repletion coefficient K and a geometry coefficient M. Data from a model inlet study and a set of real inlets have been included for comparison. All the data points appear to correlate particularly well with the geometry coefficient M.

Based on a selected definition for inlet stability, a stability coefficient is proposed. This coefficient applies to both laboratory models as well as to real inlets. A generalized criterion is obtained for determining the susceptibility of a given inlet to closure. (Author)

168 **SEELIG, W.N., HARRIS, D.L., and HERCHENRODER, B.E.** 1977. A spatially integrated numerical model of inlet hydraulics: GITI Rpt. 14, US Army Engineer Coas. Engr. Res. Cen., Fort Belvoir, Virginia, 101 pp.

This report discusses the development of a simple numerical model for the prediction of coastal inlet velocities, discharge, and resulting bay level fluctuations. The model is a time-marching model that simultaneously solves the area-average momentum equation for the inlet and the continuity equation for the bay. It is assumed that the bay surface elevation remains horizontal as it rises and falls. At each time-step the geometric and hydraulic factors describing the inlet-bay system are calculated by evaluating flow conditions throughout the inlet and by spatially integrating this information to determine coefficients of the first-order differential equations.

This model, which includes the important terms in the equation of motion, is flexible, easy and inexpensive to use, and gives a good estimate of the inlet-bay system hydraulics for various conditions. The model can be used for single or multiple inlets, bays, and seas.

This report includes the model theory and derivation, a FORTRAN computer program for solving the model equations, and instructions for use of the program. Examples are given to illustrate how the model may be used to predict coastal inlet response to astronomical tides, seiching, tsunamis, and storm surges. (Authors)

169 **SEELING, W.N., and SORENSEN, R.M.** 1978. Numerical model investigation of selected tidal inlet-bay characteristics: Conf. Coas. Engr., 16th, Proc., 1302-1319.

A spatially integrated one-dimensional numerical model of inlet-bay hydraulics has been combined with a simple sediment transport model to investigate selected tidal inlet-bay system characteristics. A parametric study has been performed using the models to determine the effect of various factors on the net direction and order of magnitude of inlet channel flow and sediment transport. Factors considered include astronomical tide type, storm surge height and duration, variation in bay surface area, time-dependent channel friction factor, and the addition of a second inlet connecting the bay and sea. (Authors)

170 **SEXTON, W.J., and HAYES, M.O.** 1982. Natural bar-bypassing of sand at a tidal inlet: Conf. Coas. Engr., 18th, Proc., 1479-1495.

Captain Sam's Inlet, a shallow unstable inlet, periodically migrates up to 3 km alongshore over a 30- to 40-year period. As the inlet migrates, sediment accumulates at the seaward terminus of the tidal inlet to form a wave-modified, ebb-tidal delta that trends downdrift. Continued sediment accumulation on the tidal-delta shoal and subsequent lenghtening of the tidal channel in a downdrift direction results in an unstable channel configuration. The ebb delta is eventually breached on its updrift side, releasing a sediment package for inlet bypassing.

The sediment-bypassing process was initiated at Captain Sam's inlet after the final landfall of Hurricane DAVID in September 1979. Initially, the newly formed updrift hurricane channel scoured 1.1 m., migrated updrift, and became the predominant tidal channel at the inlet with eventual abandonment of the prehurricane, main ebb channel. These two channels outlined a portion of the ebb-tidal delta that was freed for bypassing. The initial sediment volume contained in the baypassing shoal, above the -0.6 m (-2 ft) MSL contour, was 47,000 m^3. The sediment volume of the bypassing shoal did not change significantly until final attachment to Seabrook Island. This channel dominance and the wave-induced migration of the bypassing sediment package aided the bypassing of sand at the inlet. Immediately after filling of the prehurricane, main ebb channel on the delta, the downdrift beaches began accreting. The accretion continued throughout the bypassing process. The tidal prism and cross-sectional area reflected little change during the bypass, showing evidence of the system's overall stability. (Authors)

171 **SHIGEMURA, T.** 1976. Characteristics of tidal inlets on the Pacific Coast of Japan: Conf. Coas. Engr., 15th, Proc., 1666-1680.

Tidal inlets on the Pacific Coast of Japan were studied with respect to three characteristic variables of the throat section: (1) Throat area, A ; (2) Throat width, B ; (3) Direction of throat section, θ_{ts} . For each of these three variables, multiple regression analysis was performed stepwise by introducing external variables such as tidal prism, mean flow rate of tidal flow, wind energy, wave energy, and so on into a linear regression model. Exposure condition of the throat section to open sea was also introduced into the analysis.

First step analysis derived quite reliable results on the direction of throat section;

$$\theta_{ts} \text{ (degree)} = -60.0 + 0.88\theta_{pwv} \text{ (degree)}, \; r = 0.964$$

where θ_{pwv} is the direction of wave energy which penetrates into a backed bay through tidal inlet and r the correction coefficient between θ_{ts} and θ_{pwv} . However, results on both throat area and throat width were not satisfactory enough even after the performance of more than eighth step analysis on them.

Similar analysis was further performed on both throat area and throat width of the classified data due to the magnitude of geometrical parameters r_{as} and r_{hxb} , respectively, where r_{as} is the ratio of throat area to mean surface area backed bay and r_{hxb} the ratio of the maxiimum depth at the throat section to throat width. As a result, the former regressions on both throat area and throat width were improved remarkably. Multiple correlation of the regressions were all greater than 0.930. (Author)

172 **SHIGEMURA, T.** July 1980. Tidal prism-throat area relationships of the bays of Japan: Shore and Beach, 48(3):30-35.

The paper includes an analysis of tidal bays located along the rocky coasts of Japan. An attempt was made to determine whether the bays on the coasts of Japan comply with the cross-sectional area (A), tidal prism (P) relationships similar to those derived by O'Brien and other researchers from the tidal inlets located on sandy beaches along the coasts of the United States. The original A-P relationships were found to be quite reliable, especially when the bays under study were grouped according to the magnitude of the geometrical parameter, r_{as} (r_{as} = ratio of the throat area of a bay to its mean surface area). The values of C in each $A = CP^n$ equation were found to increase as the value of r_{as} increases. Additionally, the values of C for the bays on the coasts of Japan are all considerably greater than those found for tidal inlets on sandy beaches along the coasts of the United States. (Fields)

173 **SILL, B.L., FISHER, J.S., and WHITESIDE, S.D.** 1981. Laboratory investigation of ebb tidal shoals: Jour. Waterway, Port Coas. Ocean Div., Proc. Amer. Soc. Civ. Engr., 107(WW4):233-242.

The study was intended to aid in the development of a predictive model for ebb-tidal shoal formation. Ebb shoals were produced in a small laboratory basin, using a steady turbulent jet. A total of thirty shoals were produced from five different sediment types with differing particle sizes and specific gravities. The results of the study show that the size of laboratory shoals were most directly related to inlet width, initial average velocity, and sediment type. It was also determined that equilibrium shoal length and width are directly proportional to average inlet velocity. (Fields)

174 **SLINGERLAND, R.L.** 1977. Process, responses, and resulting stratigraphic sequences of barrier island tidal inlets as deduced from Assawoman Inlet, Virginia: Ph.D. Dissertation, Penn State Univ., 456 pp.

A process-response analysis of Assawoman Inlet, Virginia, representative of barrier island inlets on coasts with relatively high wave energy and low sediment supply, provides an alternative to the Hoyt et al., Hayes, and Kumar depositional models for laterally migrating inlets. The new channel intersection model is deduced from 10 deep cores, numerous shallow cores, four process-response mathematical models, aerial photographs, and observations of textures, bed forms, and larger scale morphologic changes over a year. In this model, inlet facies are not continuous swath or sheet sands produced by inlet lateral migration, but are discontinuous and sinuous sand bodies following old back barrier channels. This occurs because low alongshore sediment supply inhibits spit development and causes back barrier peats to be exposed in the inlet throat. Both make lateral migration difficult and act to keep the inlet located at the intersection of the retreating coastline and major back channels.

The stratigraphy of these sand bodies is some combination of subenvironment facies weighted toward ebb channel, ramp to the sea, spit platform, and lower crescentic bar environments in decreasing order of preservation potential. Bed dip directions of the major surfaces are predominantly landward (up the paleoslope), and not along shore as in the other models. A typical inlet section has coarsest grain size as its base, fines upward to midway between MLW and the channel bottom, coarsens to MLW, and then fines upward again.

On a shorter term, major inlet sand bodies respond morphologically as a system with probably a yearly period. Deposition-erosion couples occur antipathetically between ramp magin bars and beach environments. However, these relationships are not explainable as responses to daily wave climate observed over the year of study.

A one-dimensional unsteady flow, movable bed model derived in this study has potential for explaining a variety of bed-flow interactions: not sediment transport through inlets, bar migration rates, and the generation of fluvial terraces.

A factor analysis on slopes of cumulative weight versus settling velocity for the 2 mm to 63 micron fraction from 21 barrier island-inlet subenvironments classifies 55 samples into four environments: wave-current dominated, depositional beach barrier, erosional lag, and marsh channel-tidal flat. Classification based on the four Inman graphic moments of these samples produces only three groups; apparently more information is available when using the whole distribution. (Author)

175 **SLINGERLAND, R.** 1983. Systematic monthly morphologic variation of Assawoman Inlet: Nature and Causes: Earth Surface Processes and Landforms, 8:161-169.

Assawoman Inlet, Virginia, representative of small mesotidal barrier island tidal inlets exhibits systematic variations of sediment volume among certain of its morphologic elements. Sediment volume variations were calculated from topographic-bathymetric maps of the inlet system, as surveyed on 11 occasions at approximately monthly intervals by a fathometer, and plane table and alidade. Of 36 pairings among nine morphologic elements, seven show statistically significant Pearson Product Moment Correlation Coefficients. The southern ramp margin shoals are negatively correlated with the southern beach face and the northern ramp margin shoals are negatively correlated with the northern beach face on the northern spit. The southern and northern ramp margin shoals themselves are negatively correlated. The southern ramp margin shoals are negatively correlated with the fore flood tidal delta which is negatively correlated with a tidal channel on its landward side. The back flood tidal delta is positively correlated with the northern ramp margin shoals and negatively correlated with the back side of Wallops spit. These associations may be qualitatively explained using wave and tidal climate data during the sampling year plus megaripple and bedding orientations. Constructive waves tend to transfer sediment from the ramp margin shoals landward, building up the adjacent beach faces. Destructive waves tend to move sediment back to the ramp margin shoals. Waves striking the coast obliquely promote asymmetric growth of the shoals, causing the ebb jet to erode into whichever is the smaller shoal. (Author)

176 **SORENSEN, R.M.** 1977. Procedures for preliminary analysis of tidal inlet hydraulics and stability: Coas. Engr. Res. Cen., CETA Rpt. 77-8, 23 pp.

This report summarizes procedures for calculating the maximum tidal inlet channel velocity during a tidal cycle as well as the bay tidal range and phase lag (published by King 1974). Guidance for the application of these procedures to solve tidal inlet design problems for jettied inlets is also presented. The procedure may be applied to some unjettied inlets. A procedure is described whereby the inlet hydraulic response calculations can be combined with the appropriate tidal prism-inlet area stability relationship from Jarrett (1976) to predict the probable stable inlet cross-sectional area, if stability is possible. An example is presented that demonstrates both the hydraulic response and channel stability calculations for a jettied tidal inlet. (Author)

177 **SORENSEN, R.M.** 1980. The Corps of Engineers General Investigation of Tidal Inlets: Conf. Coas. Engr., 17th, Proc., 2565-2580.

The paper includes a summary of the publications generated by the US Army Corps of Engineers while conducting a General Investigation of Tidal Inlets (GITI). Research results have been published in a special report series which is divided into five categories: (1) field studies of the hydraulic and sedimentary dynamics of selected inlets, (2) analysis of historic field data, (3) numerical models of inlet hydraulics, (4) movable and fixed-bed physical inlet models, and (5) other miscellaneous inlet studies. An appendix to the paper includes a complete listing of publications in the GITI series. (Fields).

178 **SPEER, P.E., AUBREY, D.G., and RUDER, E.** 1982. Beach changes at Nauset Inlet, Cape Cod, Massachusetts 1670-1981: Woods Hole, Mass., Oceano. Inst., Tech. Rpt. WHOI-82-40, 92 pp.

A historical study of barrier beach and inlet changes for the Nauset Inlet region, Cape Cod, Massachusetts, was performed to document patterns of beach and inlet change as a preliminary to designing and carrying out field studies of inlet sediment transport; 120 historical charts from 1670 and 125 sets of aerial photographs from 1938 formed the basis for this study. Specific aspects of barrier beach and inlet change addressed include onshore barrier beach movement, longshore tidal inlet migration, and longshore sand bypassing pass the inlet. In an effort to correlate forcing events with barrier changes, an exhaustive study of the local storm climate was performed. Detailed treatment of the specific mechanisms responsible for Nauset Inlet migration episodes in a direction opposite the dominant littoral drift are treated in a companion paper by Aubrey, Speer, and Ruder (1982). Documentation of the data base available for the Nauset Area is presented herein as appendices. (Authors)

179 **STEPHEN, M.F.** 1981. Effects of seawall construction on beach and inlet morphology and dynamics at Caxambas Pass, Florida: Ph. D. Dissertation, Univ. of South Carolina, Dept. of Geol., 208 pp.

The Caxambas Pass inlet-barrier island complex, locat on he microtidal Florida Gulf Coast, is unusual in that it exhibits mesotidal morphology. Shoreline orientation, local wave refraction effects, and shoaling effects produced by a wide, shallow offshore continental shelf contribute to substantial reduction of incoming wave energy. As a result, the tidal forces tend to dominate the natural wave energy regime allowing development of mesotidal morphology.

Analysis of coastal processes reveals that the average natural wave height is 30 cm along the lower Florida Gulf Coast. Spring tidal range is 1.2 m. On Marco Island the net sediment transport is a very low 7,000 m^3 to the south.

The naturally stable Marco Island shoreline has experienced recent dramatic alteration of inlet morphology and beach erosion in excess of 100 m as a result of seawall construction near Caxambas Pass Inlet. Wave amplification, due to wall-generated reflection, creates an unnaturally large wave field near the inlet that has caused spit formation, overnourishment of the inlet interior shoals, and channel redistribution. This process has resulted in the inability of the inlet to provide sediment backpa ing, the loss of sediment storage areas, reduction of beneficial sheltering, and modification of refraction effects on the beach north of Caxambas Pass. The final result has been inlet morphologic transformation from tide dominated to more wave dominated inlet form.

Application of existing models of inlet morphology, which are based on wave and tidal energy relationships, enable evaluation of equilibrium inlet morphology on the basis of field measured wave and tidal parameters. It now appears possible to predict wave and tidal parameters based on the morphologic signature of a tidal inlet shoal. At Caxambas Pass, where wave reflection increased the local wave amplitude, comparative plots of natural and reflective wave energy levels versus tide range produced a lateral shift on Hayes' (in press) Wave/Tide Energy Diagrams which describes the change in morphology that has occurred at Caxambas Pass.

An analysis of sediment from core borings taken from offshore, the beach, and the inlet shoals indicate that sorting decreases rapidly with increasing grain size from offshore, to beach to inlet samples. Inlet terminal lobe and swash platform surface sediments were similar in texture to the active beach sediments on the adjacent barrier island. Inlet subsurface samples are generally more poorly sorted and are primarily composed of broken shell material.

The natural inlet morphology at Caxambas Pass was consistent with the mesotidal inlet morphologic model. This allowed application of model sediment transport and hydraulic patterns to the analysis and evaluation of engineering alternatives to solve the erosional conditions which exist. The morphologic and hydraulic analysis supports a "soft" engineering solution to the erosion problem. Technology transfer from the research disciplines to the applied engineering fields must be encouraged to realize optimal solutions to coastal problems. (Dissertation Abs.)

180 **STEPHENS, A.W.** 1978. The northern entrance to Moreton Bay: Orme, G.R., and Day, R.W., eds., Handbook of Recent Geological Studies of Moreton Bay, Brisbane River, and North Stradbroke Island: Queensland Univ., Dept. of Geol. Paper 8:(2)25-43.

At the northern entrance to Moreton Bay there is a large and complex tidal delta system of sand banks and channels, which stretches from Comboyuro in the southeast to Caloundra in the northwest. The system forms a barrier to the passage of beach and surf-zone sand and has trapped large quantities of sand, much of which is now being transported from Moreton Island toward the mainland. The sand banks are formed by the continuously evolving patterns of ebb- and flood-dominated channels, which are enclosed by linear tidal current ridges and often terminated by parabolic sand ridges. Traction load transport by powerful currents is appreciable producing a variety of large- and small-scale asymmetric sand ripples. (Author)

T

181 **TAYLOR, R.B., and DEAN, R.G.** 1974. Exchange characteristics of tidal inlets: Conf. Coas. Engr., 14th Proc., 2268-2289.

Measurements of the exchange characteristics at tidal inlets are presented and interpreted in the framework of an idealized conceptual model. The conceptual model considers the primary cause of exchange to be the result of the differences in flow patterns away from and toward an inlet. The efflux from an inlet is considered to occur as a separated flow whereas a sink-type attached pattern is assumed for flow toward the inlet. The combined results of these two patterns is an effective lateral mixing. Field measurements were conducted from an anchored boat, and a dye injection and monitoring approach were utilized. The measured results, expressed as "Basin Mixing Coefficients," are presented for three inlets and are interpreted in terms of the geometric and flow characteristics of the inlet and adjacent waters. (Authors)

182 **THOMSPON, W.W., and DALRYMPLE.** 1976. A history of Indian River Inlet, Delaware: Shore and Beach, 44(2):24-31.

The paper includes a discussion of the history of Indian River Inlet, Delaware. Both man-induced and natural changes are addressed. (Authors)

183 **TRAWLE, M.J.** 1981. Effects of depth on dredging frequency, Rpt. 2, methods of estuarine shoaling analysis: Tech. Rpt. H-78-5, US Army Engineer Waterways Experiment Station, Vicksburg, Mississippi, 65 pp.

The overall objective of this investigation was to evaluate the effectiveness of advance maintenance dredging in reducing dredging frequency and/or costs in the maintenance of coastal channels and harbors and to establish necessary guidelines for governing the practice. This report, the second of a series, presents an empirical method of shoaling analysis based on historical dredging and shoaling records that results in reliable predictions of future shoaling for deepened channel conditions resulting from either an increase in authorized channel depth or advance maintenance. The method presented was designed to be general enough so that it can be applied to most navigation projects without difficulty. The procedure was described step by step using an example (fictitious) project. To demonstrate how the method would be applied to real navigation projects and to point out problems that occur when evaluating real projects, selected Galveston Bay, Texas, navigation projects were evaluated and the results discussed. (Author)

184 **TRAWLE, M.J., and BOYD, J.A.** 1978. Effects of depth on dredging frequency: Tech. Rpt. H-778-5, US Army Engineer Waterways Experiment Station, Vicksburg, Mississippi, 27 pp.

The report presents the results of a survey of US Army Engineer Corps district offices to determine the extent of usage of advance maintenance dredging (overdredging). Thirty-five Corps district offices and two division offices participated in the survey. The results indicate that the decision to conduct advance maintenance dredging is determined in most cases by previous experience with the practice, and also by historical shoaling rates. (Fields)

185 **TRAWLE, M.J., and HERBICH, J.B.** 1980. Prediction of shoaling rates in offshore navigation channels: Center for Dredging Studies, Dept. of Civ. Engr., Texas Engr. Exper. Sta., Rpt. No. 232, 59 pp.

This report discusses the reliability of the "volume of cut" method for predicting dredging requirements as applied to extending estuarine entrance channels. Parameters required for the calculations include: the average yearly dredging requirements for the previous and existing entrance channel, the observed percent increase in dredging based on the yearly averages, and the natural depths along the entrance channels. In addition, the volume of cut (volume of material dredged) beyond the natural channel depth for the previous and existing channel dimensions, and the percent increase in volume of cut from the previous to existing channel dimensions must be determined. Using this method, the increase in volume of cut for the enlarged project is directly related to the channel shoaling rate.

The dredging requirements of six selected entrance channels were determined to evaluate the "volume of cut" method. The six projects include the entrance channels at Wilmington Harbor in North Carolina, Pascagoula Harbor in Mississippi, Calcasieu River in Louisiana, Sabine-Neches Harbor in Texas, Galveston Harbor in Texas, and Taquina Bay in Oregon. (Fields)

U

186 **US ARMY ENGINEER DISTRICT, Wilmington, CE.** 1977. Feasibility report on improvement on navigation, Carolina Beach Inlet, North Carolina: Appendix I:H12-30.

The prediction of shoaling rates is fundamental in the planning and design of inlet navigation channels maintained by dredging. A linear regression analysis was performed on data collected from six sandy coast inlets, and a relationship established between channel shoaling rate and the depth of an excavated channel below the natural depth. The shoaling rates were determined from hydrographic surveys from each of the inlets, including "after dredging" and subject "condition" surveys. The shoaling rate equation given by linear regression is:

$$S = 1319.5d^{-0.45}e^{0.553D} \text{ cu/yd/week}$$

where S = shoaling rate

D = depth of the bar channel cut below the average natural depth of the ocean bar along the proposed line of excavation. (Fields)

V

187 **VALLIANOS, L.** 1980. Barden Inlet, North Carolina, a case study of inlet migration: Conf. Coas. Engr., 17th Proc., 2640-2654.

The migratory pattern of a small coastal inlet was examined in terms of the factors generally acknowledged to control inlet behavior. That is, the tidal discharge which acts to flush the inlet and, on the other hand, the intrusive littoral materials depositing in the inlet environment. Specifically, a "flow conveyance index" was computed and compared to shoreline movements. The "flow conveyance in ɔx" was defined as the ratio of the mean distribution of the overall planform area of the throat of the inlet to the mean distribution of the overall planform areas of shoals within the throat of the inlet. High and low "flow conveyance index" values would correspond, respectively, to periods of relatively high and low inlet flushing conditions. A consistent pattern obtained from this analysis, wherein high and low index values corresponded with high and low shoreline movements. Additionally, the plot of rates of shore movements against rates of change of "flow conveyance index" was fitted with a simple linear regression line having a positive correlation coefficient of 0.85. Further analyses of the mean distribution of the shoals within the throat of the inlet demonstrated the cause of time-varying rates of movement of points along the sporiferous east shoreline of the inlet. Shoreline movement rates were plotted on a time-space plane and isolines of shore movement rates contoured. The result was a three-dimensional image of shore movement rates over time and distance. The position of the centroid of the inlet shoal distribution at different times was superimposed upon the three-dimensional image. This revealed that variations of shoreline movement rates along the shore at any point in time are dependent on the mean position of the inlet shoal distribution. Also, the direction of movement of the mean position of the inlet shoal distribution appeared to indicate the predominant direction of flushing action, that is, flood or ebb tides. (Author)

188 **VAN de KREEKE, J., and COTTER, D.C.** 1974. Tide-induced mass transport in lagoon-inlet systems: Conf. Coas. Engr., 14th Proc., 2290-2301.

This paper examines the tide-induced net discharge in lagoon-inlet systems. In particular, attention is given to the role inlets play in inducing a steady current.

The flow in the lagoon is described by the one-dimensional long wave equations; the flow in the inlets is described by a semiempirical equation. Both numerical and analytical techniques are employed to solve for the net discharge.

The results of the study indicate that (1) the net discharge can be significant provided the tidal amplitude to depth ratio is not small and (2) the net discharge can be considerably increased by the proper selection of the inlet dimensions. (Authors)

189 **VINCENT, C.L.** 1976. A method for the mathematical analysis of the cross-sectional geometry of tidal inlet channels: Mathem, Geological, 8(6):635-647.

Analysis of channel cross sections is hindered by lack of parameters to describe the shape of the cross section. In the situation of a sample of cross sections taken across tidal inlets, if the cross section is expressed as an observation vector, principal-component analysis can be used to derive eigenvectors of the data set. By neglecting eigenvectors that explain little variance, mathematical representation of the original data set is simplified by transformation to the eigenvector space. For 408 cross sections, each represented by a 60-component vector, three eigenvectors explain 97.5 percent of the total variance in the data set. The three-dimensional representation simplifies the task of analyzing cross-sectional shape. The physical form of the first three eigenvectors have considerable resemblance to classical types of variation noted in inlet-channel studies. The method is applicable directly to analysis of other fluvial and estuarine channels. (Author)

190 **VINCENT, C.L., and CORSON, W.D.** 1980. Geometry of selected US tidal inlets: GITI Rpt. 20, US Army Engineer Waterways Experiment Station, Vicksburg, Mississippi, 163 pp.

The geometry of the throat and ebb delta of 67 US tidal inlets is investigated. Thirteen parameters indicative of the tidal inlet geometry are defined and measured, and correlations are developed. The correlation study indicates a number of strong statistical relationships, with the minimum inlet width, cross-sectional area being particularly important. Cluster analysis and discriminant analysis are applied to the data, and the inlets are objectively classified into six groups. (Authors)

191 **VINCENT, C.L., and CORSON, W.D.** 1981. Geometry of tidal inlets: empircal equations: Jour. Waterway, Port, Coas. and Ocean Div., 107(WWI):1-9.

The paper presents data that demonstrate the existence of a empirical relationships among several physiographic parameters of an inlet. The parameters are: W = inlet width; d_a = average depth in cross-section of inlet throat at minimum inlet width; d_m = max depth in cross-section of inlet throat at minimum inlet width; L = length of channel from minimum width line to shallowest depth; d_c = shallowest depth in channel as it passes across edge of ebb shoal; and A_e = area of ebb-tidal delta using contour of shallowest depth (d_c). A_c = cross-sectional area at min. width calculated by $W \times d_c$. The parameters from 67 tidal inlets on Atlantic, Pacific, and Gulf Coasts were compared against each other using standard linear and power curve fitting analysis. A_c was found to be the most significant parameter. (Authors)

192 **VINCENT, C.M., and UVA, L.D.** 1984. Sedimentation in dredged channels and basins: prediction of shoaling rates: Conf. Coas. Engr., 19th, Proc., 44-45.

This paper discusses a technique for predicting shoaling in dredged channels where deposition of fine-grained material occurs. A comparison of hydrographic surveys is used to predict the volume of maintenance dredging. The procedure is based on empirically derived equations which describe the variation in bottom elevation with space and time. This is accomplished through definition of a sedimentation coefficient K, and equilibrium elevation CE. Once these parameters are known, annual maintenance rates (T) to differing dredging elevations (C_o) can be estimated. (Fields)

193 **VOGEL, M.J., and KANA, T.W.,** 1984. Sedimentation patterns of a tidal inlet system, Moriches Inlet, New York: Conf. Coas. Engr., 19th, Proc., 392 pp.

A detailed study of the historical development of Moriches Inlet, New York, was completed to determine the morphodynamic interaction of tidally influenced processes and the effects of man-made alterations on the inlet channel and associated flood- and ebb-tidal deltas. The inlet, located along the south shore of Long Island, breached Fire Island in 1931 and was stabilized by 1953. An extensive data base exists for the inlet system because of numerous maintenance projects over the past 50 years. While previous studies of the inlet have concentrated on tidal prism/inlet area cross-section relationships, the present study was designed to relate overall sedimentation patterns (volumetrically) to variations in the hydrodynamic regime over time. (Authors)

W

194 **WALTON, T.L.** 1974. Fort Pierce Inlet. Glossary of Inlets, Rpt. No. 2: Univ. of Florida Sea Grant Rpt. No. 3, 53 pp.

The Fort Pierce Inlet report is the second in a "Glossary of Inlets" series prepared under the University of Florida Sea Grant Program. Details are given on the history of the inlet, shoreline changes, and the climatology of the Fort Pierce area. Specifically, information is given on the astronomical tides and currents, storm tides, winds, waves, and littoral drift. (Fields)

195 **WALTON, T.L.** 1974. St. Lucie Inlet. Glossary of Inlets, Rpt. No. 1: Univ. of Florida Sea Grant Rpt. No. 2, 65 pp.

The St. Lucie Inlet report is the first in a "Glossary of Inlets" series prepared under the University of Florida Sea Grant Program. Details are presented on the history of the inlet, shoreline changes, and the climatology of the St. Lucie area. (Fields)

196 **WALTON, T.L.** 1977. A relationship between inlet cross section and outer bar storage: Shore and Beach, 45:(2).

In Florida, shoreline recession rates in the near vicinity of inlets are one to two orders of magnitude higher (10-70 ft per year) than average shoreline recession rates away from the influence of inlets (1-3 ft per year). It is apparent that these inlets act as sand sinks in their capacity to absorb tremendous quantities of sand in both their outer bars and their inner shoal areas. Unfortunately this sand is derived from adjacent beaches and causes a consequential degradation to those beaches. If an inlet is to be cut in a barrier island system, it is desirable to have an estimate of this sand volume which will eventually be lost from the surrounding beaches to the outer bar/shoals and to the inner shoals of the inlet. This paper discusses a correlation between the amount of sand stored in the outer bar of an inlet and the inlet channel cross section. Assuming one can properly estimate the inlet hydraulics and equilibrium cross-sectional area which an inlet will take, this correlation should allow a coastal engineer to obtain a rough approximation of the final consequences which the opening of an inlet will have on adjacent shorelines. (Author)

197 **WALTON, T.L., and ADAMS, W.D.** 1976. Capacity of inlet outer bars to store sand: Conf. Coas. Engr., 15th, Proc., 1919-1937.

A presentation is given of the correlation between the amount of sand stored in the outer bar of an inlet, and the inlet tidal prism or cross-sectional area. Data on tidal prism, channel cross-sectional area, and energy regime (degree of offshore wave action) were collected for 44 tidal inlets on the Pacific, Atlantic, and Gulf Coasts. The volume of sand in the outer bar/shoals of these inlets was calculated using a method from Dean and Walton

(1973). Correlations of tidal prisms with outer bar/shoal sand volumes were made for three coastal energy levels using an equation:

$$V = aP^b$$

where V = volume of sand stored in the outer bar/shoal of the inlet

P = tidal prism of inlet

a,b = correlation coefficients

The relationship between channel cross-sectional area and bar volume was made for the three coastal energy levels using the equation:

$$V = a' A^{b'}$$

where V = volume of sand stored in the outer bar/shoal of the inlet,

A = inlet channel cross-section area at throat,

a', b' = correlation coefficients. (Fields)

198 **WATSON, R.L., and BEHRENS, E.W.** 1976. Hydraulics and dynamics of New Corpus Christi Pass, Texas, A Case History, 1973-75: GITI Rpt. 9, US Army Engineer Waterways Experiment Station, Vicksburg, Mississippi, 175 pp.

A case history of the hydraulics and sedimentation of the Corpus Christi Water Exchange Pass, Texas, primarily from 1973 to 1975, is presented. This pass and the larger Aransas Pass connect Corpus Christi Bay with the Gulf of Mexico. Quantitative data on longshore sediment transport, tidal differentials across the pass, flood and ebb tidal discharge, wind waves, and local winds explain most of the bathymetric changes that have occurred in the flood tidal delta, baymouth shoreline, channel, gulf mouth, bar bypassing system, and the adjacent Gulf of Mexico beaches. Dominant onshore winds produce gulf setup and bay setdown such that, with the exception of the duration of anticyclonic events with north winds, the pass is highly flood-dominated. Heavy surf in the pass mouth and the longshore bars sweeping around the short jetties provide the gulf mouth with a large sediment supply that must be flushed by tidal discharge if the pass is to remain open. Flood dominance, combined with a long channel, requires that most of the littoral drift entering the channel be carried through its entire length to be deposited on the flood tidal delta rather than be returned seaward by ebb flow. Continued shoaling of the channel supports stability concepts of O'Brien (1931), Bruun and Gerritsen (1960), Escoffier (1940), and others which suggest that the pass is of marginal stability with a tendency toward closure. The stability diagram, conceived by Escoffier and developed by O'Brien and Dean (1972) using Keulegan's inlet hydraulics, shows the most promise for interpreting future behavior of the pass. Shoaling to a minimum cross-sectional area of less than 500 ft^2 (146 m^2) over a channel length of 500-1,000 ft (150-300 m) will probably lead to rapid closure. (Authors)

199 **WEGGEL, J.R.** 1983. Analysis method for studying sedimentation patterns. Jour. Waterway, Port, Coas. and Ocean Div., 109(2):256-260.

A method is presented for quantifying changes in water depth caused by sedimentation or scour. Using a series of bathymetric charts, a plot of surface area below a given depth versus depth is constructed. The area between the curves for successive surveys is divided by the time interval between the two surveys to yield the shoaling or scour rates. (Fields)

200 **WHITESIDE, S.D., SILL, B.L., and FISHER, J.S.** 1979. A laboratory investigation of shoaling patterns at tidal inlets: Clemson Hydraulics Laboratory, Dept. of Civ. Engr., Clemson Univ., Clemson, South Carolina, 62 pp.

In this investigation, laboratory ebb-tidal shoals were formed in a model basin. These were models of shoals characterizing tidal energy-dominant inlets as there was no wave action in the basin. Five different types of sediments were used under a variety of flow conditions and inlet geometries. All shoals generated during the study resulted in the same horseshoelike shape regardless of which sediment type or flow was used. The shape of the model shoals was strikingly similar to those at actual inlets. In real world situations where tidal energy dominates wave energy, the channel-margin linear bars are quite distinct as was very clearly observed in the laboratory. This leads to the conclusion that tidal currents are largely responsible for the formation of these deposits. Diagrams of example shoals for each sediment type are presented in Appendix A.

The resulting dimensions of the laboratory shoals were functions only of the inlet width, initial average velocity, and the particular sediment type (with appropriate critical velocity measured at the end of the shoal). The dimensions were only indirectly related to the flow rate and water depth as these variables partially determined the initial average velocity. Knowing the inlet width, sediment type, and initial velocity, nondimensional plots were generated which can be used to predict both the outside and inside shoal dimensions. However, preliminary tests would have to be run to determine the critical velocity if a sediment different from those in this investigation was used. The degree of accuracy of prediction for the width dimensions would be less since these results contain more scatter than those for the length dimensions.

For each sediment type there was a particular middepth fluid velocity (U_c) at which shoal growth terminated. This velocity, however, differed from the velocities along the side of the shoal. As discussed in Chapter 5, the isotach of critical velocity was approximately five times narrower than the resulting shoal. Thus, two different mechanisms appeared to determine the length and width of the shoals. Since sediment transport is caused by bottom shear stress and not fluid velocity, the variation of this stress may explain the difference.

The addition of longshore currents, sloping bottom, and wave action should add additional reality to the simulation of actual inlets. (Authors)

201 **WILKERSON, R.P., and SHEPARD, B.K.** 1978. Sedimentation patterns in a modern ebb-tidal delta off the South Carolina ccastline (Abs.): Geol. Soc. Amer. Abs., 10(4):202.

This study describes a modern ebb-tidal delta by the identification of subenvironments within the delta. Sediment textural parameters and current velocities are used to identify these subenvironments. The major sources of sediments are nearby river mouths which contribute finer sand material, and longshore current which contributes the coarser sand. Interaction between longshore current, waves, and current flow are the major processes responsible for the sediment deposition in these defined areas of the delta. The subenvironments are identified as the main ebb-channel, the bifurcation of the main ebb-channel, the marginal flood channels, the marginal flanking shoals, and the distal bar. Identification of subenvironments, based on textural parameters, might be used in the interpretation of the ancient ebb-tidal deltas preserved in the rock record. (Authors)

202 **WILKINSON, D.L.** 1978. Periodic flows from tidal inlets: Conf. Coas. Engr., 16th, Proc., 1336-1346.

A study was undertaken of the flow produced in the offshore region by tidal currents at the entrance of a coastal inlet. The gross features of the offshore flow structure were examined in an idealised two-dimensional model in which a sinusoidally reversing flow was discharged from an open channel into a large stagnant basin. During each period of ebb flow, the discharge from the simulated inlet developed a structure very similar to that of a starting jet, and a vortex pair was observed to form and ultimately became the dominant feature of the flow. Although variable bottom topography and longshore currents will distort the flow pattern, the rotational motions observed in these experiments would be expected to persist.

The study was restricted to coastal inlets in which the sectional area of the entrance channel is several orders of magnitude smaller than the area of water surface inside the inlet. (Author)

203 **WINTON, T.C.** 1979. Long- and short-term stability of small tidal inlets: M.S. Thesis, Univ. of Florida, Gainesville, Florida, 135 pp.

The ability to predict inlet stability is of importance when considering safe navigation through or around inlets, water quality within the adjoining bay or estuarial system, and beach erosion along the abutting shorelines. There are two aspects of this problem which must be considered when developing stability criteria, the first being the long-term stability problem. This aspect must consider the response of the inlet for a time ranging from a few months to perhaps a decade or more, during which time the inlet may either slowly shoal or remain fairly stable without significant change. The second aspect is the shorter termed problem, the problem of response under increased littoral drift and/or wave activity which may last for only a few days but which may lead to a sudden closure.

The thrust of this study is to address the problem of short-term inlet stability by developing a computer simulated idealized inlet in which the major controlling variables, including the effect of inertia on the flow dynamics, are inherently or explicitly included and which can respond to sudden or short-term variations in one or more of the variables. The model reveals that an inlet, stable under one set of littoral drift or wave energy conditions, becomes unstable and closes under a heavier littoral drift or under storm wave activity, a phenomenon which is typical of the closure of many small tidal inlets. The model has been used to simulate the closure of O'Brien Lagoon, a small tidal lagoon on the southwest coast of Florida, and the results compared favorably with prototype data collected at this inlet. (Author)

204 **WOJTAL, A.M.** 1978. The ebb-tidal delta at breach inlet, South Carolina, morphology, bedform distribution, and recent changes (Abs.): Geol. Soc. Amer. Abs., 10(4):203.

The ebb-tidal delta at Breach Inlet, located approximately 4.5 km north of Charleston Harbor, South Carolina, closely resembles the model developed by Hayes et al. (1973) exhibiting a main ebb channel, a terminal lobe, channel-margin linear bars with associated swash bars, and marginal flood channels.

Bed forms from the beach face out onto the swash bars were measured at 10-m intervals and were found to be a function of water depth, wind and wave activity, and tidal currents. The beach face is characterized by flatbeds and antidunes; the runnel contains cuspate megaripples and current ripples oriented perpendicular to the shore; and the ridge exhibits antidunes, flatbeds, and current ripples. Flood-oriented cuspate megaripples are found in the marginal flood channels.

Channel-margin linear bars are characterized by upper flow regime anti-dunes and flatbeds where water depths are minimum, and lower flow regime sand waves, cuspate megaripples, and current ripples where depths increase. The sand waves and megaripples are generally ebb-oriented and variable in height and spacing.

The ebb channel axis is presently oriented to the SSW, but has migrated between a southern and southwestern orientation during the past 36 years. As the main ebb channel assumes a southern orientation, generally by occupying one of the former ebb spillover channels, a large swash bar migrates landward on the downdrift side of the inlet. This mechanism appears adequate to explain the downdrift offset inlet configuration at Breach Inlet. (Author)

205 **WRIGHT, L.D., SONU, C.J., and KIELHORN, W.V.** 1972. Water-mass stratification and bed form characteristics in East Pass, Destin, Florida: Marine Geology, 12:43-58.

Density contrasts between the water of Choctawhatchee Bay and the Gulf of Mexico result in sharp vertical and horizontal stratification in the northern part of the East Pass near Destin, Florida, during flood and a portion of the ebb tidal phases. As a consequence of this stratification, flood tide currents are swiftest and of longest duration in the deeper layers within dredged channels. Ebb currents attain their velocity and duration maxima in the upper layers of the water column. Accordingly, bed form asymmetries indicate that bed load transport is flood dominated in the channels and ebb dominated over shoals. Vertical density homogeneity resulting from greater mixing in the seaward reaches and at the mouth of the inlet channel is accompanied by bidirectional sand transport. (Authors)

INDEX

END

FILMED

1-86

DTIC